INFLUENCE OF DISASTER RISK MANAGEMENT APPROACHES ON FOOD CROP PRODUCTION UNDER THE CHANGING CLIMATE IN SIAYA COUNTY, KENYA

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A Thesis Submitted to the School of Disaster Management and Humanitarian Assistance in Partial fulfilment of the Requirement for the Degree of Doctor of Philosophy Degree in Disaster Management and Sustainable Development of Masinde Muliro University of Science and Technology

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DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award

Signature …………………………... **Date …………………………….**

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CDS/H/01-53106/2018

CERTIFICATION

The undersigned supervisors certify that they have read and hereby recommend for submission by Masinde Muliro University of Science and Technology a research thesis entitled; **"Influence of disaster risk management approaches on food crop production under the changing climate in Siaya County, Kenya."**

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DEDICATION

I dedicate this research thesis to my father Fredrick Ogenga Omule and my mother Jane Ogenga Omule who perceive formal education as the engine for Development and sustainability amidst risks and vulnerabilities in the society.

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ABSTRACT

Globally, an estimated 29% of people are faced with food insecurity due to the changing climate which negatively impacts food crop production hence reducing the efforts of Sustainable Development Goal Number 2,” End hunger” by 2030. Kenya, with 80% of the land area being arid and Semi-arid, experiences frequent and persistent floods and droughts respectively. In Siaya County an estimated 80% of farmers are involved in rain fed subsistence growing of crops such as maize, sorghum, millet, beans, sweet potatoes and cassava. However, agricultural production has negatively been impacted by the changing climate leading to crop failure or low crop yield. The overall objective of the study was to examine the influence of disaster risk management approaches on food crop production under the changing climate in Siaya County. The specific objectives of the study were; i) to establish the socio-economic characteristics which influence disaster risk management approaches in Siaya County, ii) to determine the disaster risk management approaches related to climate change in Siaya County, iii) to determine the relationship between the climate trends and food crop production in Siaya County, iv) to evaluate the effectiveness of disaster risk management approaches on food crop production in Siaya County. The study used descriptive survey, correlational and evaluation research designs. A sample size of 385 households was determined using creative research system for the study where sampling techniques comprised of Multistage and proportionate sampling for household respondents, purposive sampling for Key informants and quota sampling for the Focus Group Discussions. Secondary data were obtained from the publications, Journals, internet sources and newspapers. Daily rainfall and temperature were sourced from the Kenya Meteorological Department (KMD) and subjected to Mann-Kendall test for Temp. and rainfall trends; Standardized Precipitation Index; statistical regression analysis and use of Rainbow Software. River gauge data obtained from WRA was analyzed using river flow duration curve. Descriptive and inferential statistics were used to correlate climate trends and crop production; and also, to analyze quantitative data with the help of Statistical Package for Social Scientist (SPSS) Version 20.0 for percentages, frequencies and level of significance while narrative analysis was used to analyze qualitative data. Findings show that all the socio-economic characteristics influenced disaster risk management except education with a correlation coefficient of 0.072, not statistically significant at 0.697, $p > 0.05$. Corrective disaster risk management approach was highly related to climate change with a stronger positive relationship $r = 0.95$, significant at 0.001 $p < 0.05$. There is a strong negative relationship between climate trends (drought) and food crops production with a correlation coefficient of -0.540 significance at 0.05, p value = 0.05 while floods and cumulative food crop production displayed a positive negligible relationship, correlation coefficient of 0.507 though not significant at 0.164, p value > 0.05. Lastly, findings show that the approaches are not effective in food crop production with a statistical significance at 0.087 $p > 0.05$. The study concludes that the approaches positively influence food crop production, however with low level of significance. There is need for a concerted multi stakeholder approach to improve the DRM Approaches effectiveness towards food crop production in Siaya County. The findings will help both national and county governments in policy formulation in contribution to the SDG number 2.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

CBDRM	Community Based Disaster Management
DRMA	Disaster risk Management Approach
FAO	Food Agriculture Organization
FGD	Focus Group Discussion
GoK	Government of Kenya
IGAD	Intergovernmental Authority on Development
IPCC	Intergovernmental Panel for Climate Change
KALRO	Kenya Agricultural and Livestock Research Organization
KII	Key Informant Interview
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
LM	Lower Midland
MMUST	Masinde Muliro University of Science and Technology
MoA	Ministry of Agriculture
MoALF	Ministry of Agriculture, Livestock and Fisheries
NACOSTI	National Commission of Science, Technology and Innovation
NDMA	National Drought Management Authority
NGO	Non-Governmental Organization
SD	Standard Deviation
SDG	Sustainable Development Goal
SPSS	Statistical Package for Social Scientists
UNDP	United Nations Development Program
WPF	World Food Program

DEFINITION OF OPERATIONAL TERMS

Adaptation: This is the process of adjusting to the new conditions such as of the changing climate. This term was used to refer to the adjustments of agricultural systems in response to future and existing climatic stimuli and their impacts on food crop production that would affect food security in the study area.

Climate Change: This describes a change in average weather conditions of climate elements such as wind speed, humidity, atmospheric pressure, cloudiness, temperature and precipitation sustained for at least 30 years that may lead to change in climatic pattern in a given region and time leading to occurrence of extremes weather events such as drought and floods in Siaya County that negatively impact food crop production.

Disaster risk management: The application of disaster risk reduction policies and strategies which have the ability to prevent new disaster risks, reduce existing disaster risks and manage residual risks while contributing to the strengthening agricultural systems resilience hence reduction of disaster losses of food crop production hence from the negative impacts of climate change.

Disaster Risk Management Approaches: These include; Prevention where the best way to address a disaster is by being proactive; Mitigation which aims to minimize the loss of food crops that would result from a disaster; Preparedness which entails getting ready for anticipated disaster impacts like droughts and floods on food crop production; Response, ensures activation of the systems to reduce the negative impacts of droughts and floods on food crops; and Recovery as ensuring agricultural activities are adequately restored after the losses incurred from the impacts of droughts and floods.

The study will use the following approaches;

i) **Prospective disaster risk management approach –** This is a strategy that is founded on agricultural practices such as a) Greenhouse gas reduction activities, b) Land use planning, c) Agroforestry, and d) early warning climate information activities that seek to avoid the development of new or increased disaster risks such as floods, drought and pest and diseases on agricultural production from climate change

ii) **Corrective disaster risk management approach -** This is a strategy that is founded on agricultural practices such as a) Soil and water management strategies, b) Drought tolerant crops, c) Pests and disease management, d) Crop diversification, e) Improved storage, and f) Flood management that address and seek to lessen any negative impact of climatic disaster risks such as droughts and floods which already exist and has the potential to reduce food crop production or cause total failure on food crop production.

iii) **Compensatory disaster risk management approach -** This is a strategy that is based on activities such as a) contigency funds, b) crop insurance, c) safety nets and d) agricultural subsidies that strengthen the social and economic resilience of individual households involved in food crop production in the face of residual risk from climate change that cannot be effectively reduced through corrective approach.

iv) **Community-based disaster risk management approach -** This is a strategy consisting of activities such as a) prediction of hazards, b) implementation of the risk reduction activities, c) monitoring of the implementation of the risk reduction activities, d) planning of the risk reduction activities and e) risk analysis that promotes the involvement of potentially or affected communities by climate change negative impacts to enhance food crop production.

Drought: This is a period of drier than normal condition which results into a deficit of water to support agriculture in a given region and time hence impacting negatively the agricultural production in the affected regions. There are four types of droughts namely; **Meteorological drought** which refers to an extended period of below-average precipitation in a particular area. **Agricultural drought** which refers to the impact on agriculture by rainfall deficits, soil moisture deficits, reduced ground water and reduced reservoir levels needed for irrigation impacting negatively on crop growth and plant development resulting in decreased agricultural productivity. **Hydrological drought** refers to evidence of low water supply in streams, reservoirs and groundwater levels after prolonged meteorological drought which is linked to deficiencies in surface and groundwater resources. Finally, **Socio-economic drought** which occurs when the demand for an economic good exceeds the supply caused by deficit in water supply, for example, farmers may lose income if a drought destroys their crops. This study focused on meteorological drought as it's often seen as the initial stage of drought since insufficient rainfall can lead to decreased soil moisture, diminished water accessibility, and subsequent consequences for water resources, agriculture, and ecosystems. Siaya suffers from all the 4 types at different seasons within the various crop growing periods

Effectiveness: The term effectiveness was used in this study to demonstrate the possible contribution of the disaster risk management approaches towards increased food crop production under the change climate.

Floods: Overflow of water due to increased amount of rainfall received and submerges land that is normally dry in a given location. There are two types of floods such as river floods that is the overflow of water from the river channel due to exceedance in river capacity onto the adjacent lands. Secondly, flash floods that is a sudden rush of water in low lying areas as a result of intense rainfall in a given location normally of higher grounds. Siaya experience the two types of floods as the river floods caused by the exceedance of capacity of River Nzoia and the flash floods due to accumulation of excess rain water on flat grounds submerging crops. The study focused on flash floods since it occurred and affected a vast region of the study area unlike the river floods that only affected the riverine communities of the study area.

Food crop production: Food crop production refers to the process of cultivating crops such as maize, beans, Sorghum, cassava and sweet potatoes that are primarily grown for human consumption. This research investigated the application of Disaster risk management approaches under the changing climate to increase food crop production in Siaya County.

Food Security: This is as a situation where all people at all times have social, physical and economic access to sufficient, safe and nutritious food that meets their dietary need and food preference for an active and healthy life. The research investigated the application of Disaster risk management approaches under the changing climate to increase food crop production. Increased food crop production has the potential of increasing food availability, access, stability and utilization hence informing food security and ending hunger.

Influence: This is the ability of factors such as the disaster risk management approaches to cause measurable desired outcomes in enhancing food crop production under the changing climate.

Mitigation: Mitigation refers to the act of reducing severity of something or of a harmful occurrence. This term was used in this study to refer to the agricultural practices such as soil and water management, and pest and disease management that were applied to reduce the severe impacts of climatic risks of droughts and floods on food crop production in the study area.

Sustainable Agriculture: Farming that meets the need of existing and future generations while also ensuring profitability, environmental health and social and economic equity

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Climate change has led to increased climatic risks particularly caused by droughts and floods which negatively influence food crop production therefore impacting on their potential for sufficient and safe food provision (Mbow *et al.*, 2019). The inadequacy caused by the inability to produce enough food is however mitigated through disaster risk management approaches such as prospective, corrective, compensatory and community-based approaches in many parts of the world in order to assist communities to cope with the climate change risks and sustainably increase food crop production for vulnerable populations (Azad *et al.*, 2020).

According to USGCRP (2014), climate change resulting in increased temperatures can lead into heat stress on crops hence reducing yields while more extreme weather events like droughts and floods have caused an increased negative impact on food crops in all the stages of development of the crops in the farm from germination, flowering and during harvesting. According to Farooq *et al*., (2023), Food and Agriculture Organization estimates that under the high warming scenario from climate change, global crop yield and mainly food crops could decline to 17% by 2050. Currently, changes in climate globally which have led to increased frequency and intensity of weather events like droughts and floods have impacted the world food availability. According to USDA (2022) United states of America which supplies over 25% of the global market with food and mainly of food crops and have been affected directly by the negative impacts of climate change translating to reduction in global food hence food insecurity.

Access to food is a basic human right as stated in SDG number two "end hunger, achieve food security, improve nutrition and promote sustainable agriculture". Achieving food security entails measures that mitigate risk factors such as droughts and floods that negatively impact agricultural food crop production. According to the World Food program (1996), food security is based on individual, household, national and regional situations where all people at all times have physical, social and economic access to sufficient, safe, nutritious food that meets their dietary needs and food preferences for active and healthy lives. Therefore, people who fail to produce food because of climate change impacts suffer from food insecurity. Food insecurity can trigger or cause chronic hunger, starvation, malnutrition and even death. Global statistics show that by June 2023, 5,145361 million people had died of hunger due to food insecurity.

The severest food insecurity in many parts of the world is majorly triggered by climate change that mainly causes drought and floods that negatively impact food crop production. Globally, an estimated population of 1.3 billion people are food insecure giving a 10% increase from the 2021 estimates which, were mainly attributed to the changing climate (WFP, 2022). Food insecurity is still on the rise and achievement of the Sustainable Development Goal Number 2," End hunger", to achieve food security and improved nutrition is far from being achieved by 2030. There are various corrective approaches such as supplemental irrigation, climate smart agriculture and conservational agriculture aimed at achieving food security by mitigating the impacts of both floods and droughts, however climate change has continuously threatened their success, such that there is still increased crop failure and loss of livelihoods in both temporal and spatial scales (Barret, 2002).

Africa’s food insecurity has been on the rise since the 1970s, it is estimated that 140 million are facing acute food insecurity (GNAFC, 2022). Sub Saharan Africa is the worst affected by food insecurity due to mainly climate change risk factors such as droughts and floods which have led to the increase in the number of people suffering from chronic undernourishment in the region. Statistics show that in sub–Saharan Africa, food insecurity increased from 22.2% to 22.5% which translated into 9 million more suffering from food insecurity in sub–Saharan Africa compared to the 2021 statistics (FAO, 2022b). The rise is attributed to the increase in number of the undernourished in West Africa by a half and another third increase in East Africa.

Poor countries and mainly developing sub–Saharan Africa countries are expected to experience the worst effects of climate change. Reason is that poor countries have limited capacity to mitigate the impacts of climate change mainly droughts and floods. They also highly rely on climate sensitive resources such as subsistence rain fed small-scale farming (IPCC 2018). The area that has been greatly affected by food insecurity in Africa is the semi-arid Horn of Africa, which is highly moisture constrained and experiences extreme temperatures and erratic rainfall (IGAD, 2018; WFP, 2019). Therefore, ensuring food security for the growing African population will require innovation in agricultural practices with regard to climate change negative impacts mitigation through the disaster risk management approaches to increase the capacity of the agricultural systems resilience.

The Horn of Africa (Djibouti, Somali, Uganda, Eritrea, Ethiopia, Sudan and Kenya) with a population of over 160 million people has approximately 27 million people constantly prone to food insecurity due to the negative impacts of droughts and floods from climate change. This hence makes it one of the most vulnerable regions in the world. The worst affected countries in the Horn of Africa are Ethiopia (8.1 million), Sudan (6.2 million), South Sudan (6.1 million) and Kenya (6.0 million) (IGAD, 2018; WFP, 2019)

Kenya is one of the countries in the Horn of Africa with 80% of the land area being arid and Semi-arid, a condition that exacerbates the frequency and magnitude of extreme droughts and floods. This situation subjected populations of approximately 4.4 million people (27%) of populations in the ASAL regions like in Siaya county to a cute food insecurity between March – June 2023 (IPC, 2023) and approximately 5.4m suffering from acute food insecurity in the Horn of Africa (UN, 2022). Extreme climatic risk event such as droughts that occurred from 1975, 1977, 1980, 1983/84, 1991/92, 1995/96, 1999/2000, 2004/2005, 2008, 2009/10, and 2011 threatened lives of millions of people causing food insecurity that led to famine and hunger (Mateche, 2011). Onchiri *et al*. (2016) observe that, the extreme droughts experienced in 2007, 2009 and 2015 caused devastating food insecurity, for example in 2009 an estimated 3.5 million people in marginal agricultural lands lost their livelihoods and this led to severe food shortages, increased food prices (maize which is a staple food recorded US$45 per 90kg bag, in 2011 more than a half increase from 2010 and 70% above world price (UNECA, 2020). The drought affected 47 counties within the eight regions of Kenya and led to a decline in food crop production which was highest at the Coast 44.5%, Eastern 36.5%, Central and Western at 4.5% each, while Rift Valley and Nyanza lost at 19.75% and 17.5% respectively during the period (GoK, 2012). Table 1.1 show drought years in Kenya, people who were at risk of food insecurity and the food crop lost, mainly Maize as a staple food in Kenya in metric tons.

Table 1.1: Drought years, people at risk and food crops lost in Kenya

SN	Year	People at Risk of hunger	Food crops (Maize) lost in metric tons (Mt)
1	1975	16,000	2,275
2	1977	20,000	152
3	1980	40,000	4,413
4	1983/84	200,000	1,978
5	1991/92	1.5 million	1,412.85
6	1995/96	1.4 million	1,907
7	1999/2000	4.4 million	2,013
8	2004/2006	3.5 million	7.85
9	2008	1.4 million	800, 000
10	2009	10.0 million	800, 000
11	2010	11 million	150, 482
12	2011	13.million	101,157
13	2016/2017	2.7 million	100,000
14	2022	4.5 million	540, 000

Source: Institute for Security Studies (2011) and ASAL Humanitarian Network (2022), GoK (2004), National Policy on Disaster Management, Kenya and FAOSTAT (2022)

Equally, Kenya has also experienced severe floods, for example, the 1961- 1962 and 1997 - 1998 El-Nino associated floods that affected most parts of the country causing loss of crop lands and livestock (UNDP, 2015). Other notable severe floods occurred in 1982, 1985, 2001, 2002, 2014, 2016 and 2018. The heavy rains in 2001, 2014, 2016 and 2018 caused floods in the Central, South, North, Western and Eastern parts of the Country.

According to GoK (2018a), the floods disrupted livelihoods by damaging crop land of over 38, 562 acres in the period 2016 – 2018. The loss of food crops affected food security in Kenya. This agrees that climate change negative impacts are one of the major contributing factors to food crop loss in many parts Kenya (OCHA 2018). Table 1.2 shows flood years in Kenya, people who were at risk on hunger due to reduced food crop production and the food crop mainly maize as a staple food in Kenya in metric tons.

Table 1.2: Flood years, populations at risk and area of coverage in Kenya

SN	Year	People at Risk of hunger	Food crops (Maize) lost in metric tons (Mt)
1	1961	>10,000	2,933
2	1963/64	>10,000	3,752
3	1968	>10,000	2,930
4	1977/1978	300, 000	909
5	1982	4000	1,029
6	1985	10,000	679
7	1997/98	1.5 million	753
8	2002	150,000	1,066
9	2003	170,000	340
10	2014	300,000	124
11	2016	34, 000	1,183
12	2019/2020	260, 000	133

Source: GoK (2004), National Policy on Disaster Management, Kenya / Opere (2013) Floods in Kenya; and KRCS (2023) Reports on floods impacts and losses; and FAOSTAT (2022)

One of the counties in Kenya which experiences perennial climate change (drought and floods) that affect food crop production is Siaya. The County lies within the Lake Victoria basin where 60% of the population depend on subsistence agricultural production mainly; maize, beans, sorghum, Millet, cassava, sweet potatoes and maize as the staple food crop. The agricultural production is severely constrained by frequent droughts such as in the years 1975, 1977, 1980, 1983/84, 1995/96, 1999/2000, 2004-2006, 2008 – 2010 (King-Okumu, 2021) and erratic rainfall leading to low food crop production in Siaya County (GoK, 2016).

According to Abura *et al*. (2017), given the frequent climatic change in Siaya County, there have been noticeable impacts of droughts and floods on the food crops making the county 80.7% thus leading in terms of food insecurity within the Lake Victoria basin. Siaya, Busia, Homa Bay, Baringo and Wajir face greatest food shortage at 60% while

Turkana County experiences extreme food shortage at 86% nationwide WFP (2016; and GoK 2021a).

In order to mitigate the impact of climate change on food crop production in Siaya, it’s of importance to investigate disaster risk management approaches aimed at improving the agricultural production in a changing climate scenario in Siaya. Disaster risk management approaches are categorized as a) prospective, b) corrective, c) compensatory, d) community based, and d) local and indigenous people disaster risk management. Approaches that have been used to mitigate the impacts of climate change geared towards improving food security status include; a) climate smart agriculture, b) conservational agriculture, c) crop insurance and d) contingence fund during the impact (Kirchman *et al*., 2016). It is therefore necessary to adopt approaches that are initiated and implemented at the community level in mitigating the climate change impacts. The strategies hold on the potential of improving resilience by strengthening local capacities that are important for improving food security of vulnerable households. Mitigating the climate change shocks and stresses require intensive investment, mainstreamed climate risk management that will strengthen food security through integration and coordination. (Middle miss and Parrish, 2010). Therefore, the study aimed at examining the influence of disaster risk management approaches on food crop production under the changing climate in Siaya County.

1.2 Statement of the problem

Siaya County is located in the Lake Victoria basin, which is one of the regions categorized as Arid and Semi-Arid Lands in Kenya (GoK, 2021). An estimated 80% of the farmers in Siaya County are involved in rain fed subsistence growing of crops such as maize, sorghum, millet, beans, sweet potatoes and cassava. However, agricultural production has been negatively impacted by the frequent droughts and floods leading to low production and hence food insecurity in most of the seasons. This is therefore an indication of lack of resilience of food crops leading to increased susceptibility to the changing climate.

Some researches that have been carried out on food crop production problem in Siaya include first, (Odunga, 2019) on food production and food security of smallholder farmers and their support by County Government of Siaya. This research aimed at investigating the contribution of the relevant policies by the County government in improving small scale holder's crop production to enhance foods security in Siaya. Secondly, (Abura *et al*., 2017) on Rainfall and Temperature variations and their impact on food production in Siaya County which aimed at investigating the possible impacts of the climate variability on food production. Unlike the two researches stated, this study is based on the influence of disaster risk management approaches on food crop production under the changing climate in Siaya County. This approach strengthens agricultural system's resilience for food crop production. It is against this background that this study therefore, sought to establish the disaster risk management approaches which will ensure that Siaya County is food secure even in the changing climate episodes in Kenya.

1.3 Overall Objective

To establish the influence of disaster risk management approaches on food crop production under the changing climate in Siaya County

1.4 Specific Objectives

i) To establish the socio-economic characteristics which influence disaster risk management approaches for food crop production in Siaya County.

ii) To determine the disaster risk management approaches related to climate change in Siaya County, Kenya

iii) To determine the relationship between the climate trends and food crop production in Siaya County, Kenya

iv) To evaluate the effectiveness of disaster risk management approaches to food crop production in Siaya County, Kenya

1.5 Research Questions

i) What are the socio-economic characteristics that influence disaster risk management approaches for food crop production in Siaya County

ii) What are the disaster risk management approaches that are mostly related to climate change mitigation in Siaya County?

iii) What is the relationship between climate trends and food crop production in Siaya County?

iv) How effective are the disaster risk management approaches in enhancing food crop production in Siaya County?

1.6 Justification of the Study

The study was conducted in Siaya County based on the fact that Siaya is one of the Counties in the Lake Victoria Basin that is categorized as Semi-Arid experiencing both drought and floods annually therefore adversely affecting her food crop production. This study therefore, sought to; establish the socio-economic characteristics which influence disaster risk management approaches, determine the disaster risk management approaches that are climate change related, determine the climate trends relationship with food crop production and evaluate the effectiveness of the disaster risk management approaches on food crop production in Siaya County.

This section explains three types of justifications as academic, policy and philosophical justifications of the study illustrating the importance of the study.

1.6.1 Academic Justification of the study

Studies such as Abura *et al.* 2017 contributed to the existing knowledge on impact of climate change on food security while Odunga 2019 informed the small-scale holders on the county government support mainly in terms of farm inputs towards food production. There was therefore knowledge gap in terms of the approaches used to avoid, reduce and manage the residual risks in food crop production under the changing climate. The findings will inform and add knowledge to the households of Siaya County on the sustainable disaster risk management approaches which enhances food crop production in the changing climate scenario. The findings of this study will add valuable information to the County government, National Government agencies, Ministry of Agriculture and KMD (Kenya Meteorological Department) and other stakeholders on the trend of climatic conditions in relation to the food crop production and the risk management approaches to enhance food security.

1.6.2 Policy Justification of the study

Disaster risk management 2017 policy of Kenya aimed at building a disaster resilient nation through different sectors. In this context, a resilient agricultural system against climate change risks such as droughts and floods. The study findings and recommendations will also help the relevant stakeholders and the government in developing and strengthening policies with regard to enhanced risk reduction measures to strengthen resilience and capacities in the changing climate for increased food crop production and food security.

1.6.3 Philosophical Justification of the study

This study was founded on the philosophy of positivism. Positivists believe that only factual knowledge gained through observation and including measurement is trustworthy. This study acquired climate data from relevant source as Kenya Meteorological Department (KMD), crop yield data from Department of Agriculture, irrigation and livestock of Siaya County and River gauge data from the Western Regional Flood Management. These data were analyzed and interpreted objectively independent of the researcher`s judgement and interests hence yielding quantifiable findings. These findings will lead to evidence-based recommendations on sustainable disaster risk management approaches suitable for risk sensitive development. This would enhance resilience in agricultural systems hence improving food crop production under the changing climate for food security as an SDG number 2.

1.7 Scope of the study

The study was conducted in Siaya County in the sampled locations as East Yimbo and North Sakwa of Bondo Sub County, North Ugenya and East Ugenya of Ugenya Sub County, and North Alego and Usonga of Alego Usonga Sub County. This was with the main focus on the influence of selected disaster risk management approaches such as prospective, corrective, compensatory and community based on food crop production. The study targeted a population of 385 household heads who grow food crops (from three sub-Counties namely Alego Usonga, Ugenya and Bondo) with the target food crops including; Maize, beans, Sorghum, millet, cassava and sweet potatoes production. The major stakeholders included the representatives from County Government of Siaya; County Disaster management Committee; Department of Agriculture, irrigation, livestock and fisheries; Water Resource Authority; Kenya Meteorological Department (KMD) representatives also constituted the target population. Data for climate trends was sourced for the period 1992-2021 while crop data was for the period 2011-2022. The study was carried out between October to November 2022 in the study area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature to conceptualize the research theme based on the specific objectives as i) socio-economic characteristics which influence disaster risk management approaches, ii) disaster risk management approaches that are climate change related, iii) relationship between climate trends and food crop production, iv) effectiveness of the disaster risk management approaches on food crop production. The chapter also discusses a conceptual framework model employed for the study.

2.2 Socio-economic characteristics which influence disaster risk management approaches for food crop production

In this study, socio-economic characteristics were reviewed as a complex interplay of factors such as age, gender, education level, marital status, size of the family, employment, monthly income and related economic activities that defines a human population in a given location and within time. Globally, these factors have shown a changing trend and diversities. However According to Braveman *et al*., (2021), measuring the global socio-economic status has proved to be challenging due to the widened variations and diversities in socio-economic characteristic from the many countries of the world. According to Psaki *et al*., (2014), these varying characteristics have and are expected to influence human population development by differently impacting on their livelihoods hence making it an important determinant of development. Socio-economic status as a determinant of development context is with regard to how they may influence adoption of approaches by communities towards mitigating the risks of food crop loss associated with climate change negative impacts. This has the capability to foster a risk sensitive development towards attainment of food security which is sustainable development goal number 2, "end hunger", improve nutrition and promote sustainable agriculture.

Notably, some studies have focused on the socio-economic characteristics of households and their influence on approaches used to mitigate climate change negative impacts on agricultural systems in the world. Stojanov *et al*., (2016) that found out that demographic characteristics of communities in the North Eastern part of Czech Republic significantly influence choice for different approaches and mainly corrective related to restoration of the damages caused by climate change rather than prospective approaches involving investing costly measures in mitigating the negative impact of climate change affecting different environmental systems such as agriculture.

In Africa, Kreibich *et al*, (2005) study revealed that demographic characteristics of households have contributed to the choices and the adoption of different disaster risk management approaches in relation to mitigation of climate change negative impacts. The study posits that level of income of household heads and of the entire household determines the community's level of managing the risks associated with climate change negative impacts. According to Kreibich *et al*., (2011), the low income households were highly involved in low cost measures such gathering precautionary information that constitutes community based disaster risk management approach and relocation to safer places from floods as an activity in corrective disaster management approach, medium income households mainly associated with insurance of crops against floods and droughts as a compensatory disaster risk management approach, while the high income households were involved in high cost measures such as building dykes and land use planning that are activities in prospective disaster risk management approach in mitigating climate change (Okunola and Bako, 2021).

Ekegren *et al*., (2021) found out that socio-economic characteristics of the household and heads significantly influence their participation on plans, implementation and monitoring of the risks associated with climate risks and help take precautionary measures as a community-based risk reduction approach towards building resilience of different systems such as of agriculture for improved food crop production. This was also in tandem with Ihemezie *et al*., (2018) that demographic characteristics such as literacy levels and income of household heads determined the kind of approach taken towards mitigating risks from the changing climate in most sub-Saharan countries.

Additionally, Access to information founded on one’s education level (Yameogo *et al.*, 2018), and income levels and family size (Chete, 2019) of households in communities are major factors influencing choice for the adaptive disaster risk management approaches in mitigating climate change on agricultural systems in the rural sub-Saharan Africa. Compensatory disaster risk management approach has been is significantly influenced by demographic characteristics such as level of income of households through provision of contingency funds by mainly governments to help them prevent adverse impacts of the extreme weather evens such as floods and droughts on agricultural production (Weru *et al.*, 2017).

Related studies in Kenya such as Mogaka *et al*., (2021) on socio-economic factors influencing the choice for climate smart agricultural practices in Western Kenya where

Siaya County in located found out that household age, education level, gender, duration of practice, form of land ownership influenced the adoption of the CSA practices. Climate smart agricultural practices are under the corrective disaster risk management approach in relation to their ability to lessen or reduce the existing negative impact of climate change on food crops. According to Paustian *et al*., (2016) CSA practices are part of rehabilitation and protection of the climate and specifically on the media for agriculture such as land for sustainable food crop production.

Additionally, founded on the prospective disaster risk management Ng'ang'a *et al*., (2017) and Abubeker *et al*., (2017), findings revealed that socio-economic factors had a positive influence on the agro-forestry practices among Kenyan farmers towards greenhouse gas sequestration and improvement of soil quality for quality and quantity food crop production. Relatively, Beyene *et al*., (2019), findings also found out that age of the household heads, land tenure systems and educational level, income and farming experience had a significant influence to the adoption of climate change mitigation approaches. However, the study reiterated that most studies have investigated on the influence of socio-economic factors on adoption of approaches used on mitigation of climate change in isolation.

According to GoK (2023), Siaya County performs below the national average on most socio-economic indicators. It scores an HDI of 0.46 which is below the national average of 0.56 where poverty is prevalent in the county and manifests itself in other socio-economic outcomes such as poor nutrition, health, and education as well as a lack of access to basic services adding to unemployment is a major challenge in the county, especially among the youth. The majority of the population is employed in fishing and agricultural activities, with limited opportunities in commercial ventures and public service. As more young people enter the workforce due to rapid population change, the pressure on available employment opportunities is expected to increase. High population density, water scarcity, falling food production combined with effects of climate change are increasing food insecurity in the county.

The interplay of these socio-economic attributes in the county dictated by the challenges from each attribute such as low-income levels, unemployment, high population density and insufficient access to means of production due to gender disparities are assumed to have a significant influence on the choice and adoption of the kind of disaster risk management approach in mitigating climate change in the county. This therefore resonates with Mogaka *et al*., (2021) on the socio-economic factors influencing adoption of climate smart agriculture in the western part of Kenya where Siaya County was one of the sampled for the study that age, gender, education level. Land tenure and income had a significant influence on the mitigation approaches to climate change with the focus on improving food crop production.

2.3 Disaster risk management approaches and actions related to climate change

This section addresses objective (ii) of the study which is to determine the disaster risk management approaches related to climate change in Siaya County, Kenya. According to IPCC (2018), climate risks related to food crop production are projected to have an increase with global warming at 2.1°C. This hence necessitates strategies to manage the related risks to ensure resilience of food crop production systems. Disaster risk management therefore is the employment of various disaster risk reduction policies and strategies to avoid impending disaster risks, reduce existing disaster risk and manage residual risks with the aim of strengthening resilience of given systems such as of agriculture (UNISDR, 2017). It therefore comprises the whole systematic and conceptual framework of measures that are closely linked to each other and that are taken before, during and after a natural hazard occurs with the aim of limiting adverse impacts of natural events in the society.

According to Mohinuddin (2022), strategies to reduce the disaster risk are categorized into two i.e., reducing the vulnerability of the population itself from the natural hazards such as drought and floods, and preventing the occurrence of new hazards such as deforestation along the riverbanks that may lead to flooding and increased drought occurrence. However, there seems to be a common understanding and agreement on the aim of application of the measures to manage disaster possible impacts and losses from natural hazards such as floods and drought based on avoidance, reduction and compensation from the residual risks management.

Globally, agreements such as in UNISDR (2017) states that disaster risk management employment and application should be guided by the Sendai Framework for disaster risk reduction 2015 – 2030. With this regard, there is need to have nexus in practices between sustainable development and Climate change adaptation plans with the aim of achieving the greatest objective of risk reduction globally, regionally, nationally and at community levels in food security. Similarly, the Paris agreement in 2015 obligates all actors to develop and strengthen various risk management approaches in response to climate change hazards (UNDRR, 2020). Complementarily, according to IFRC (2019) the United

National and related International Community have spearheaded formulation of policies that have seen integration of related disaster risk management approaches and climate change. These efforts are expected to enhance resilience to some of the pillars of sustainability like food security through sustainable food crop production in the wake of climate change in the whole world.

Regionally, African has witnessed negative impact of approximately 157 million people from disasters in Sub Saharan Africa. In this context, UNDRR (2020) document that the disaster impacts have mainly resulted from hydro meteorological hazards such as floods and droughts triggered by climate change. With this regard, the regional organizations and related authorities through African Union resilience development strategy and action plan have made efforts to mitigate the negative impacts of climate change (AUC, 2022). These have been done through development of risk management approaches that integrates climate change mitigation measures and agricultural production. According to COMESA (2022), this is expected to be cascaded to the sub regions that have been frequently affected by various climatic hazards, dominantly drought, floods and pests and diseases mainly to build resilience of the agricultural systems and improved food crop production in different regions within Africa.

In the Kenyan Context, disaster risk management policy approaches have increasingly been developed and institutionalized into the County Integrated Development Plans (CIDP) in various county governments. According to GoK (2022), the efforts have been complemented by the legal frameworks and critical instruments that are geared towards aligning disaster risk management such as Kenya Climate Change Response, Strategy and National Disaster Risk Management Policy. Through the CIDPs, various counties have domesticated policy such as the Siaya County climate change action plan (2023-2028) that brings together various stakeholders from the county government and the community themselves towards climate change intervention using the disaster risk management approaches for increased food security (GoK, 2023). This is also in line with the Kenya climate change risk profile (GoK, 2022) that has aims replicated to the county levels through various Counties including Siaya climate change risk profiles documenting various on-farm and off-farm climate change mitigation and adaptation strategies for improved agricultural resilience. However, Nyandiko (2020) points out at the low-key relation and integration of the DRR approaches with climate change impact management in implementation with the focus on building a food secure country by instilling a resilient agricultural system for improved food crop production n mostly at the County levels.

In this range of relevant frameworks and policies from global perspective to national levels on DRR, such as of Paris agreement having to direct reference to Sendai framework, to African Union climate change and development plan, there exists coherence in terms of disaster risk management approaches in implementation under the changing climate (Kelman, 2015). According to (UNISDR, 2015), disaster risk management therefore are categorized into five approaches as prospective disaster risk management, corrective disaster risk management, compensatory disaster risk management, community-based disaster risk management and local and indigenous people approach to disaster risk management.

2.3.1 Prospective disaster risk management **approaches**

This approach is based on activities that address and seek to avoid the development of new or future disaster risks (UNDRR 2022). These activities therefore focus on addressing disaster risks that may develop in future if disaster risk reduction policies are not put in place. Related to climate change are better land-use planning, disaster-resistant water supply systems and agro-forestry, early warning, construction of dykes, and Greenhouse gas emissions reduction (Mbow *et al.,* 2019). It is therefore evident that measures to avoid future disaster risks are important when the potential climate related hazards such as floods and droughts are identified and analyzed for preparedness purposes (Herron *et al*., 2015). In this sense, the disaster risk management plan if implemented effectively then the risks of climate change impact can be avoided or limited on food crop production.

Globally, various activities under the prospective approach have been practiced in ensure effective reduction of climate change negative impacts on food crop production. This is with reference to studies (Mattsson and Nisanka, 2018) which indicated that just like in any other natural resources, climate change is having direct impact on land leading to land degradation hence loss of soil fertility. Loss of soil fertility hence, have led to low food crop yield or total failure of food crop production hence increased chances of food insecurity in the whole world (Mbow *et al*., 2014). Agro-forestry, land use planning and greenhouse gas reduction as some of the activities under prospective approach has been used worldwide to improve the effectiveness of future climate suitable for increased food crop production (IPBES, 2019). According to Agro-forestry network (2018), trees inside and outside forests, and more explicit inclusion of the agro-forestry and the integration of agriculture, land use and forestry as used worldwide have the potential and have indicated the capacity to increase their individual effectiveness on climate change adaptation and mitigation for an improved food crop production for a food secure world.

In Sub Sahara, there have been experiences of highly variable climate that have affected food crop production (IPCC, 2019a). This has led to various initiatives towards application of various activities under the prospective disaster risk management approaches to mitigate the negative impacts of climate change. Small scale farmers in Africa have continued to practice land use planning in their own capacity coupled with agro-forestry which have had a ripple effect on the greenhouse gas reduction (Swallow and Ochoa, 2016). Evidently, land use planning, agro-forestry and its effects on greenhouse gas reduction have been applied for soil fertility improvement and livelihood enhancement through increased food crop production in the sub saran Africa (Kugedera, 2019).

Kenya is not exceptional in the application of the prospective approach activities towards food crop production. Use of various early warning systems of both modern and indigenous, land use planning and agro-forestry have been applied in both small and large scales to improve the future climate for sustainable food crop production. According to Mugure and Oino (2013), practices like agro-forestry have remained to be an important aspect of sustainable land use in agricultural production for improved food crop production. However, studies have shown that there is low rate of adoption of the practices that need to be enhanced in many parts of the rural Kenya. In many parts of Kenya and mainly the rural where small scale farming is practiced, land use planning and practices have become a factor to complement efforts of agro-forestry for sustainable land management to protect and conserve land from degradation (Kariuki, 2021). This according to studies has significantly reduced soil degradation and low food crop yields.

Siaya County just like other counties in Kenya, practice of various activities under prospective approach have occurred to avoid future risks of climate change that may lead to low or total failure of food crops. According GoK (2023) Siaya county action plan 2023 -2028, Siaya County is very susceptible to climate change and the county has invested on prospective approaches such as agro-forestry, land use planning, early warning and greenhouse gas reduction activities to lessen future disaster risks that may be as a result of climate change. By implementation of the county climate change plan itself therefore is a commitment towards mitigation of the future negative impacts of climate change in the county on agricultural sector and food crop production particularly.

Relatively, MoALF (2016) climate risk profile of Siaya County identified other prospective approach activities as off farm practice that included early warning that have assisted farmers to lessen the future risk of climate change as droughts and floods to improve food crop production in the County. It is evident that Siaya county is therefore involved in the prospective disaster risk management approach with activities that are both off farm and on-farm with regard to early warning, agro-forestry, land use planning and greenhouse gas reduction activities to build agricultural resilience for enhanced food crop production in the Siaya County.

2.3.2 Corrective disaster risk management **approach**

This approach is based on activities that address and seek to lessen disaster risks which already exist and which need to be managed and reduced immediately. Some of the risk management practices under climate change that can improve food crop production are crop diversification, growing drought tolerant crops, pest and disease management activities and supplemental irrigation practices during drought. These have mainly been implemented through Climate Smart Agriculture (CSA) which is an integrated approach to managing landscapes, cropland, livestock, forests and fisheries that address the interlinked challenges of food security and climate change (De Pinto *et al*., 2020). Climate-Smart Agriculture (CSA) is therefore an approach designed to help the people who manage agricultural systems respond effectively to climate change.

The CSA approach pursues the triple objectives of sustainably increasing productivity and incomes, adapting to climate change and reducing greenhouse gas emissions (mitigation) where possible. It is anchored on three pillars which are; increased productivity, adaptation and mitigation (Parry 2016). Very relevant to corrective risk management approach to this study is the adaptation pillar. The adaption practices enhance resilience by reducing vulnerability to floods and droughts, pests, diseases and other climate risks and shocks that can also improve the capacity to adapt and grow in faces of longer-term stresses like shortened seasons and erratic weather patterns (Ghassem *et al*., 2012).

According to World Bank (2020), the Climate Smart Agriculture practices as corrective measures to lessen the climate change impact risk on food crop production should contribute immensely to the progress of Sustainable Development Goals (SDGs) for climate action, poverty and eradication of hunger. According to Jun *et al*., (2022), since climate smart agriculture was proposed in 2010 by FAO, it has widely been adopted and used worldwide in reducing the negative impacts of climate change and improve food crop production. It means that globally, adaptation strategies through climate smart agriculture are in implementation with main focus on adaptation to the changing climate and ensure resilience of the agricultural systems for food improved food crop production.

Africa at the regional level has been involved in adaptation strategies meant to adjust the agricultural systems to the changes changing climate. According to IPCC (2007), climate smart Agriculture involves taking the right measures such as adaptation measure to reduce the negative effects of climate change by making the appropriate adjustments in the agricultural systems. According to Oluwole and Ifeoma (2015), some of the adaptation measure that have been practiced in most of the African Countries are planting drought tolerant crop such as wheat which requires low amount of rainfall than rice in Nigeria, Burkina faso and Senegal as implemented among small scale farmers. Corrective related practices in other parts of Africa are crop diversification such as in South Africa and Tanzania as a way of spreading disk of loss of food crops that also serves as an insurance against rainfall trend unpredictability in the agricultural food production. Changing cropping patterns and calendar of planting is also practiced among African countries like in the Central Africa due to the trends of uncertainties of extreme weather events in that part of the continent (Urama and Ozor, 2011).

Kenya, just like other countries in the continent of Africa has also adapted to the changing climate by practicing various corrective practices. Addition to crop diversification, planting drought tolerant crops, supplemental irrigation and pest and disease management are conducted by small scale farmers (Oluwole and ifeoma, 2015). Studies (Sylvestri *et al*., 2012; Legesse *et al*., 2013) have shown that communities mostly living in the ASALs of Kenya are mainly dominated by the small-scale farmers who entirely rely on rainfed Agriculture hence giving them no any other options other than being engaged in corrective approach to reduce effects of climate change. According to Nyasimi *et al*., (2014), Conservation Agriculture is one of the practices under corrective approach and the first CA project was launched in the year 2003 and was supported by FAO where up to date the practice has intensified to improve food crop production in the wake of climate change.

Siaya County has also been involved in corrective disaster risk approach to reduce the negative impacts of climate change. This approach is implemented mainly by small scale farmers through arrange of activities such as crop diversification, growing of drought tolerant crops, supplemental irrigation and pests and disease management. This is asserted by Climate risk profile of Siaya County 2022 that detailed these activities under on farm climate change mitigation strategies to enhance agricultural crop resilience and improve food crop production (MoALF, 2016). Similarly, Mogaka *et al*., (2021) on the climate smart agriculture practices adoption by small scale farmers to improve soil quality in Siaya County as one of the counties in the Western region of Kenya, mulching, intercropping, and drought tolerant cropping are practiced to with the main focus of improving food crop production. These practices are corrective as they reduce the existing negative impacts of the changing climate on the rainfed dependent agriculture involving maize, beans, sorghum, cassava and sweet potatoes.

2.3.3 Compensatory disaster risk management **approach**

This approach is based on activities that strengthen the social and economic resilience of individuals and societies in the face of residual risk from the climate change that cannot effectively be reduced by corrective practices (UNISDR, 2015) where the risk management activities include preparedness, response and recovery. In the context of food crop production under the changing climate, this study focused on the compensatory aspect of risk management as recovery activities as a mix of different financing instruments, such as national contingency funds, contingent credit, insurance and reinsurance of crops and social safety nets such as cash transfer programs that are pertinent to enhancement of food security in the after math of climate change negative impacts.

According to FAO (2019), climate change has remained the main cause of low agricultural production hence insufficiency in food provision mainly from food crops in many communities worldwide and hence compensation as a residual risk management remains a key approach in transforming agricultural sector. Compensatory risk management approach therefore was meant to help farmers recover from the agricultural losses and also enhance access to food after the negative impacts of droughts and floods as a result of climate change.

Globally, compensatory approach has been practiced to transfer risks through crop insurance from climate change, aid timely and sufficient response towards the lost food crops through contingency funds, increased accessibility of the required inputs for food crop production through subsidies and cushion the most affected by droughts and floods through cash transfer programs that can sustain the affected before the next harvest after the negative effects on that might have led to crop loss. Compensatory practices such as farm input subsidies have been adopted since the green uprising in Latin America and Asia in 1960 and 1970s while many countries of the world have continued to depend on them for improved food crop production from the changing climate (Wang *et al*., 2019). Other compensatory approaches such as contingency funds and crop insurance to transfer risks from the small-scale farmers to insurance companies and authorities such as governments have also been in use over time in the who world. According to (World Bank, 2022), India as just one of the countries that has well established National Agricultural Insurance scheme that is meant to reduce farmers vulnerability to natural disasters such as droughts and floods has managed to improve their food crops amidst increasing human population and changing climate.

Sub Saharan Africa has also adopted agricultural subsidies for crop yield improvement where according to Ambajo (2022) subsidies are mainly of fertilizers, seeds, pesticides, mechanization, labour and other financial aid. Compensatory practices such as agricultural subsidies, crop insurance have the potential to increase crop yield, food security and economic wellbeing of small-scale farmers in Africa (FAO, 2020). However, Pauw and Thurlow (2014) asserted that most small-scale farmers in developing countries have not embraced the subsidies and crop insurance as compensatory approach towards climate change mitigation on food crops which is due to their low economic disadvantage. This has therefore subjected a majority on other compensatory practices such as relying on supplemental feeding, food for work and cash transfer to the most vulnerable in the community such as the elderly to negative climate change impacts.

Kenya through concerted multi-stakeholder efforts has over the years formulated policies and integrated compensatory approach into agricultural production to protect livelihoods. According to Badiane *et al.,* (2016), Kenya like any other African country has employed universal subsidies schemes since 1960, Kenya has also put strategies on agricultural subsidies, developed food crop insurance from drought, pests and floods, initiated cash transfer and contingency funds by the National Government as part of broader risk management framework and as key strategy to de-risk agriculture (GoK, 2020).

Kenyan government under the comprehensive crop insurance program that cover main food crops such as maize, beans, sorghum is involved in agricultural loss compensation allocates 50% of its funds to small scale food crop farmers yearly (GoK, 2020). This initiative is implemented in at least thirty Counties with Bomet registering the highest 3610, the least as Kakamega with 15 while Siaya County having 233 registered small-scale food crop farmers. In addition, the Siaya County government has been helping farmers by providing agricultural subsidies since taking charge in 2013. This includes providing seeds and fertilizers at a reduced cost. For instance, in 2014, they offered maize and sorghum seeds worth 4.9 million Kenyan shillings and fertilizer subsidies of 8.5 million Kenyan shillings. The total spent on subsidies over the past three years is 37.1 million Kenyan shillings, not including the money used to buy tractors for subsidized plowing services (Ambajo, 2022).

Various compensatory activities are in implementation ranging from agricultural subsidies such as hired tractors, seeds, fertilizers, and also relating to supplemental feeding programs and social safety nets among the most vulnerable populations in the communities. According to the GoK (2022) since devolution of agriculture, Siaya County Government has enrolled a number of agricultural subsidies that included subsidized maize and sorghum seeds amounting to Ksh 4.9 million (US $ 37,692) and fertilizer to a value of 8.5 million (US $ 65,385) in the last financial year. This evidenced compensatory disaster risk management is implemented where the County Governments procures the inputs on behalf of the small-scale farmers and give to them a lower price to increase access of the inputs to a majority which is expected to increase food crop production in the study area.

Addition to the fertilizers and seeds, the county Government has also given access to the small-scale farmers tractors for hire at a reduced price of Ksh. 3000 (US $ 23) per ha for ploughing services. Other related compensatory activities are “Inua Jami” program for the elderly vulnerable populations in Siaya County. According to Omondi *et al*., (2023) implementation of cash transfer on the most vulnerable populations in the community such as the elderly and the female headed household in Siaya County have had a positive influence on more income generating and farming practice hence increasing food crop production.

2.3.4 Community-based disaster risk management approach

This approach promotes the involvement of potentially affected communities in disaster risk management at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for disaster risk reduction. Community members are normally the affected and interested during and after a disaster and are normally the first to responds to save and prevent the elements at risk such as crops from the adverse negative impacts of the disasters such as floods. It would therefore be prudent and important to involve the affected communities in management of the hazards.

According to Lao PDR (2016), Community based approach in disaster risk management recognizes the fact that in the post disaster situation, the first people to respond are always from the community and there is need for recognition of the capability of the resources that are locally available and their vulnerabilities. This is also a fact that it’s through local knowledge, that the community understands and can help identify and integrate the indigenous practices from climatic elements, weather signs, perceptions and beliefs with the scientific orientations of risk management.

In the context of food crop production and climate change, community-based disaster risk management approaches are meant to build the capacity the community to enable them conduct flood and drought assessment, planning, implementation and monitoring and evaluation of the strategies implemented as local disaster risk reduction. In this view, Azad *et al*., (2020) reiterates that disaster management has moved from relief and response to risk management through disaster risk reduction where community involvement is key and there is a significant shift from reactive top down to proactive community-based approach.

According to Phiri (2014), community-based risk management approach became popular worldwide from the years 1980s ensued failure of traditional disaster management approach of disasters such as drought and floods on food crops. This has then become a trend in many parts of the world by prioritizing on the community members capabilities to manage risks such as related to climate change as the ones who brand the greatest burden when the disasters such as of drought and floods occur on the systems such as of agriculture that they solely depend on for food security. Community based approach activities such as observation, prediction, analysis of the risk and creation of early warning have been used and particularly apparent to plans that are focused on building resilience to both hazards and climate change hence improved yields in many parts of the world such as in China, India and Taiwan (Gallagher *et al*., 2020).

Community based disaster risk management approach have been practiced in many parts of Africa and mainly in the sub-Saharan Africa to predict and observe droughts, floods and pest's occurrence and their potential negative impacts on food crops. Community-based Disaster Risk Management (CBDRM) applications are proving to be powerful tools for enhancing food crop production in Africa. According to FAO (2021), this approach empowers local communities to work together with government officials to identify and mitigate risks specific to their regions. By leveraging their traditional knowledge of weather patterns, soil conditions, and historical disasters, communities can develop effective strategies for food security (FAO, 2015). Examples of successful CBDRM applications in Africa are Ethiopia and Senegal among other African countries. In Ethiopia, communities have implemented indigenous monitoring and observation of weather patterns while in Senegal, farmers have participated in indigenous early warning systems and that have helped them efficiently respond to flood occurrence and avoid its impacts on crops (UNDRR, 2022). These localized solutions, driven by community knowledge and collaboration, are leading to more sustainable and resilient food production systems.

In Kenya, community members are actively involved in predicting climatic hazards. According to Musimba *et al*., (2018), on the community participation on drought risk management in Kilifi, states that the central role of community involvement is not only beneficial but as the key actors in managing the negative climate change impacts on vulnerable systems such as those that are rainfed dependent. Participation draws on local knowledge of weather patterns, passed down through generations that can provide clues about upcoming droughts or floods by collaborating with scientific experts, residents can integrate traditional wisdom with modern forecasting methods (Okoth, 2012). This combined approach strengthens the accuracy and relevance of climatic hazard predictions, empowering the community to prepare and adapt to future challenges.

Relatively, in Siaya County, community members have participated in various activities related to disaster risk management and specifically those that allow their involvement. Some of the activities were mainly in observation, monitoring, prediction of the weather element such as wind, birds, insects and clouds movement form one direction to another and dynamics using methods of indigenous knowledge and experiences hence early warning to farmers of the possible extreme climate risk such as of drought, pest invasion and floods that may impact negatively the crop fields.

2.4 Climate trends and food crop production

This section addresses objective (iii) of the study which sought to determine the relationship between climate trends and food crop production in Siaya County, Kenya. Climate change refers to long-term shifts in temperatures and weather patterns. Common weather patterns include hot and dry weather, wet and rainy weather, and cold weather. Such shifts can be natural, due to changes in the sun's activity, large volcanic eruptions or due to Human activities. According to IPCC (2007), Climate change describes a change in average conditions of climate elements such as temperature, precipitation, wind speeds and direction, humidity sustained for at least 30 years that may lead to change in climatic pattern in a given region and time leading to occurrence of climatic extremes such as drought and floods. Climate change may be directly or indirectly attributed to human activities like deforestation and intensive and extensive agriculture that alters the composition of global atmosphere and which is in addition to natural climate variability observed over a comparable period of time (Holden, 2006).

In the event of climate change, erratic weather events such as reduced or increased amount of rainfall and temperatures occur hence impacting on food crop production differently in different locations and times (IPCC, 2022). Through the changes in the climate, there are chances of possible increase or decrease in food crop production in both spatial and temporal scales. However, the negative impacts have over time outweighed positive impacts in many regions. According to FAO (2022a), higher temperature can reduce crop yield where $1^{0}c$ rise in temperature may reduce major crop yield by 5 – 10% of the total annual food crop production to add to the possible heat that can also shorten growing season and reduce critical development of food crops during growing seasons. Equally, erratic rainfall patterns have also been identified as having negative impacts on food crop growth and development hence reducing the annual food crop production (FAO, 2015).

Global climate change has occurred throughout the earth history in pattern and this has been determined by a range of factors like astronomical, atmospheric, geological and oceanographic differences that vary naturally over decades (IPCC, 2019a). The difference in the natural forces alters the global climatic patterns in precipitation and temperature among other climatic elements. Notably, findings indicate that the change in the global climate is highly contributed by the anthropogenic activities that involve intensive and extensive combustion of carbon-based fossil fuels like oil and coal. Other factors are attributed to the astronomical factors based on the energy from the sun that drives the earth climate. According to the NOAA (2019), global temperature has increased at an average of 0.07 Celsius degree per decade since 1880. According to Lindsey and Dahlman (2020), from 1900 to 1980, a new temperature record was set on average every 13.5 years. However, since 1981, it has increased every 3 years with the five warmest years between 1880 and 2019 occurring since 2015 while nine of the ten warmest years occurring since 2005. Therefore, in average, the global temperature has increased and this in turn increases evaporation hence increase in the global precipitation. According to NOAA (2019), the global precipitation has increased at an average rate of 0.08inches per decade since 1901.

Climate trends founded on the changing temperatures and varying amount of rainfall received leading to either drought or floods have led varying trend in the food crop production globally. According to Loladze (2014), it's true that higher CO2 levels can slightly benefit some plant growth; however, the bigger picture from studies shows a decrease in crop yields. Therefore, food crop production is highly sensitive to climate change where, it gets affected by the long-term trends in average rainfall and temperatures. If there is no attention to address climate change, things could get much worse. Some models predict a staggering 17% plunge in essential crops like maize, wheat and rice by 2050 (FAO, 2016). This highlights the urgent need for world to adapt farming practices to guarantee food security for a world with more and more people to feed.

African is the most affected continent by the negative impacts of climate change resulting from floods and drought. Africa has warmed by over 1degrees Celsius since 1901 (IPCC, 2021) with a prediction of reduced precipitation likely in the Northern Africa and South West parts of Southern Africa by the end of the century. However, there has been a shift in the great Horn of Africa from very dry climatic condition before 2018 to high amount of rainfall received causing floods in 2019 and 2020 (IPCC, 2019a). Africa therefore faces a perfect storm when it comes to climate change and food security. Already struggling with scarce water and a reliance on rain-fed crops, the continent is expected to see temperature increases exceeding the global average where, some regions may experience increase of 1.5 to 4 degrees Celsius by 2100 (UNCCD, 2021). This warming will likely bring more frequent and severe droughts, along with unpredictable rainfall patterns. Studies by the FAO and World Bank predict these changes could cause significant drops in crop yields, ranging from 5% to a staggering 50% depending on the location and specific crop (World Bank, 2022). With less food being produced, millions of Africans could face hunger, making food security a critical challenge.

Varying extreme climatic trends causing drought and floods has been experienced since 1960 in Kenya (Mcsweeney and Coomes 2011). The changes in climatic conditions are attributed to the complex tropical climate that varies significantly between regions due to the country's variable topography and the influence of several regional and global climatic processes (Abbass *et al.*, 2022). According to GoK (2018a), there is a mean annual temperature increase of 1.0 degrees that is an average rate of 0.21 degrees per decade since 1960 while the rainfall change has also been noticed however, the change does not show statistically significant trends due to the varying topography with varying annual amount of rainfall received in Kenya. However, the changing patterns of climatic conditions such as drought and floods have continuously affected subsistence food production mainly maize, beans, sorghum, millet and vegetables that is 98% dependent on rainfall (Thornton and Herrero, 2015).

Kenya therefore faces a growing threat to its food supply as climate change pushes temperatures higher than the global average. This warming trend is a double-edged sword, bringing more frequent and harsher droughts alongside unpredictable rainfall patterns. According to (Onyango, 2016), these changes could cause significant drops in crop yields, ranging from 5% to a worrying 28% depending on location and specific crop. This decrease in harvest could lead to crop failures, jeopardizing the livelihoods of Kenyan farmers who rely on the food crop production for their survival.

Siaya County just like the other parts of Kenya receives a bi modal rainfall pattern with long rains occurring between March and May (MAM) while short rains occurring between September October and November (SON) (GoK, 2013). According to Abura *et al*., (2017), Siaya County has no significant rainfall trend but displays variations in rainfall and Temperature over time (1986 – 2015). However, there are experiences of increased trends of floods and drought frequencies and intensities that are attributed to climate change. These events have led to low food production of rainfed crops mainly maize, beans, sweet potatoes, cassava and sorghum causing persistent famine in the study area (GoK, 2023).

2.5 Effectiveness of the disaster risk management approaches on food crop production

The literature reviewed in this section addresses specific objective number (iii) of the study which was to evaluate the effectiveness of disaster risk management approaches on food security in Siaya County, Kenya. Effectiveness of disaster risk management approaches is based on the disaster risk management plan which sets out goals for reducing disaster risks together with related actions to accomplish the objectives

(UNISDR, 2015). The plan is expected to identify, evaluate and spell out the risk reduction measures. In this study, the objective is to enhance food crop production under the changing climate. Through the disaster risk management plan, disaster risk management approaches related to climate change are tested through evaluation to find their effectiveness in enhancing food security in the wake of climate change.

According to IPCC (2014), historical information indicates that people and societies all over the world have adjusted and are copying with the changing climatic hazards such as droughts, pests and floods hence reducing the risks of low food crop production to varying levels of success. The efficacy of the disaster risk approaches internationally have been attributed to climate change policies adoption where countries around the world have normalized implementation of the disaster risk management approaches that fall under prospective, corrective, compensatory and of community based to solve the climate change inflicted challenges such of food insecurity. Rasmussen (2018) on adaptive governance and climate change in West America reiterated that most communities have focused on their own climate related problems and significantly reduced the risks of losses such as food crops from the climatic hazards mainly floods, pests and diseases and drought. However, UNISDR (2014) indicates that to achieve success on sustainable development, there is need for nations all over the world to integrate the disaster risk management approaches into their agricultural development plans to realize their wholesome effectiveness in food crop production.

Disaster risk management approaches have gained effectiveness in improving food crop production and generally for entire agricultural production globally. Studies UNCCD (2022) show that application of disaster risk management approaches that encompass prospective, corrective, compensatory and of community based have contributed significantly (25%) improved crop yield by strengthening resilience of food crops against changing climate impacts in the world. Therefore, communities all over the world are engaged in agricultural activities that are geared towards preventing, reducing negative impacts, transferring risks and involving the community in the proper management of climate change hazards such as drought and floods on food crops.

According to FAO (2023) disaster risk management actions are a powerful tool not only to combat global food insecurity but also to ensure a sustainable food supply. This is by the fact that they become effective on the basis that they aid in improving soil health, crop diversification, increase resistance to drought and pests, and reduce the greenhouse gasses that in turn reduce global warming. However, quantifying the disaster risk management approaches effectiveness in percentage or degree is difficult based on the variations in their applications and varying climatic conditions in the world.

Regionally, Africa and specifically sub-Saharan African countries have been extremely affected by the changing climate leading to crop failure on rainfed agriculture and increasing the risks of food insecurity to populations (WMO, 2022). Related researches on climate change and food security have been conducted to test the effectiveness of risk reduction strategies like adaptation strategies and mitigation strategies to reduce the impacts of climate change on food crop production (WFP, 2021).

According to IPCC (2021), Africa has indicated improvement though of low significance on climate related risk reduction through implementation of the Africa Climate Business Plan (ACBP) where it set 17 billion dollars to meet the investment needs for climate adaptation and resilience that includes land use management, Climate Smart Agriculture and Greenhouse Gas reduction in the Continent. African countries such as Zambia, Mali, Le Sotho and Zimbabwe in Africa though the Support of ACBP have led to development and implementation of Climate smart agriculture plan (crop diversification, supplemental irrigation through rehabilitated water sources) that has indicated increase in food security for rural poor to between 7- 15% indicating effectiveness of the risk management approaches (UNECA, 2020). However, IPCC (2019b) indicates that with the projection on global warming increase to 1.5degrees Celsius between 2030 to 2050, which calls for more actions on climate change disaster risk reduction to increase food crop resilience and reduce vulnerabilities among the rural poor in Africa.

Kenya being one of the Countries in Sub Saharan Africa and specifically located in the Horn of Africa is characterized by negative impacts of climate change hence affecting food security. This has enabled Kenya to be considered for financial assistance mechanism as a compensatory disaster risk management approach to a tune of 200 million dollars (World Bank, 2020). These initiatives have yielded positive outcomes and generated critical lessons and transformation on food crop production for food security. Additionally, Kenya has shown to be one of the most successful Countries in Sub Saharan Africa at 40% powered with renewable energy hence reducing the GHG into the atmosphere that could increase global warming.

These activities that have successfully been tested in the communities tend to be practiced by the community themselves and adopted by other communities to build their own unique road of transformation towards disaster risk reduction and sustainable development such as in Siaya County to reduce the risk of food insecurity from the climate change negative impacts. However, according to Simtowe *et al*, (2021), Kenya' crop yield mainly of the dominant food crops such as maize have shown a downward trend despite application of various risk management approaches such as crop diversification, soil and water management, soil fertility management and government subsidy initiatives on inputs hence indicating a significant ineffectiveness of the disaster risk management approaches to food crop production for food security.

2.4 Knowledge gaps

The study identified knowledge gap on socio-economic characteristics in light of the widening variations and diversities with regard to choices and application of varied disaster risk management approaches to mitigate negative impacts of climate change.

Secondly, the study identified knowledge gap on integrating disaster risk management approach to mitigation of climate change impacts to food crop production.

Thirdly, the study identified knowledge gap relating to missing data making on statistical relationship between climate trends and food crop yields on the global perspective difficult.

2.5 Conceptual Framework

This study was guided by the conceptual framework model shown in Figure 2.1 to indicate the relationship between disaster risk management approaches (independent variable) and food crop production (dependent variable). Based on the fact that food crop production is affected by the extreme climatic conditions mainly floods and droughts, various climate change related disaster risk management approaches may have a significant positive impact in enhancing food crop production. Some of the disaster risk management approaches are: prospective (land-use planning, disaster-resistant water supply systems, agro-forestry, early warning systems, greenhouse gas emissions reduction and improved food crop storage), Corrective (climate smart agriculture practices), Compensatory (Crop farming insurance, cash transfer, contingency funds and credit fund) and Community based approaches (Participation in assessment of hazards, planning, implementation and monitoring and evaluation of the implementation of the approaches), while the basic indicators were based on food crop production of maize, sorghum, beans, cassava and sweet potatoes. The existing influencing variables (intervening variable) that were tested between the approaches and food crop production were mainly socioeconomic characteristics such as age, gender, marital status, education level, family size, income of household heads, land tenure systems, duration of residence, and climate trends and patterns mainly of droughts and floods.

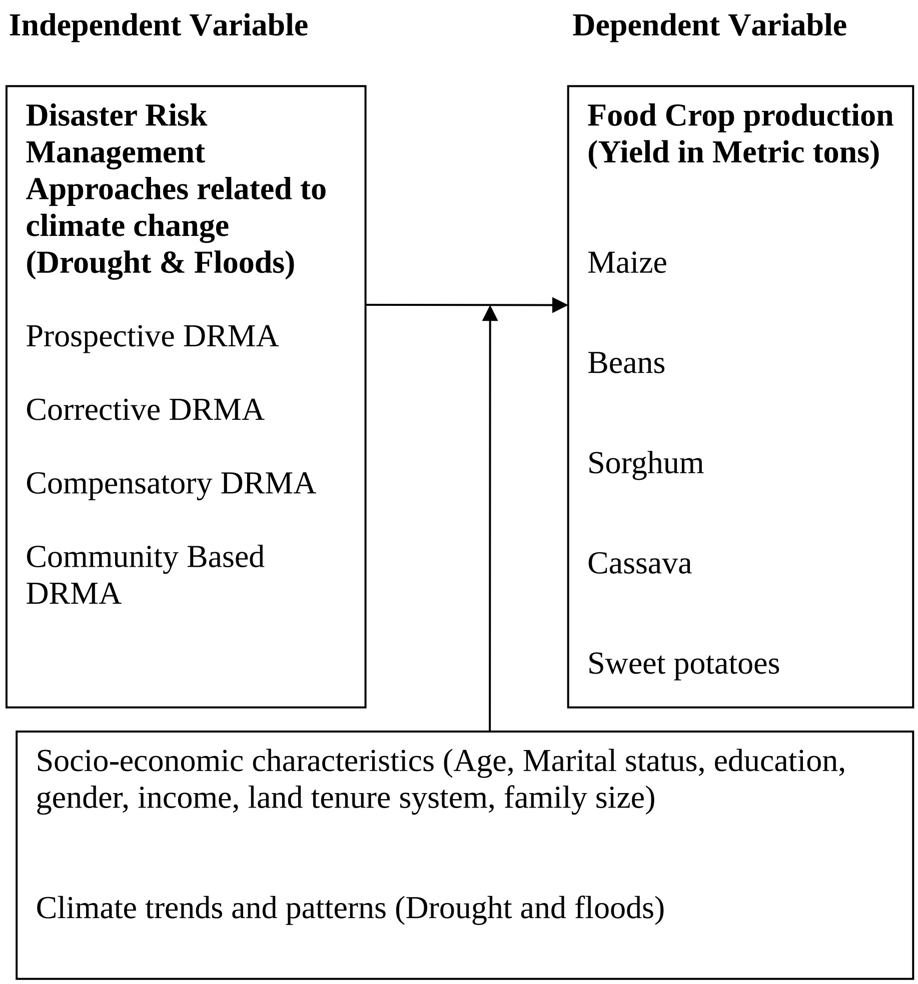

Figure 2. 1: Conceptual Framework model

Source: Researcher (2021)

The expected out comes from the study were increased crop yield as a result of prevention of disaster risks that are climate related as drought, floods and pest and diseases; improved soil moisture; strengthened food crop resilience to drought and floods; increased residual risk management through compensation and improved participation of households in planning, implementation and monitoring of the disaster risk management approaches in enhancing food crop production in Siaya County.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses, the study area, study population, research design, sampling strategy, data types, tools of data collection, data processing and analysis, reliability, validity, ethical consideration, assumptions, data analysis, and presentation of results. The other sections include the geographical location, the administrative components of the study area, climate of the study area, and socio-economic characteristics of the study area.

3.2 Study Area

The research was conducted in Siaya County, which is one of the six counties in the Nyanza region. Siaya County has a land surface area of 2,530 km^2 with a water surface area of 1,005 km^2. The water surface area forms part of Lake Victoria. It approximately lies between latitude 0º 26´South to 0º 18´ North and longitude 33º 58´ and 34º 33´ East (GoK, 2015). The study area map is as presented in Figure 3.1.

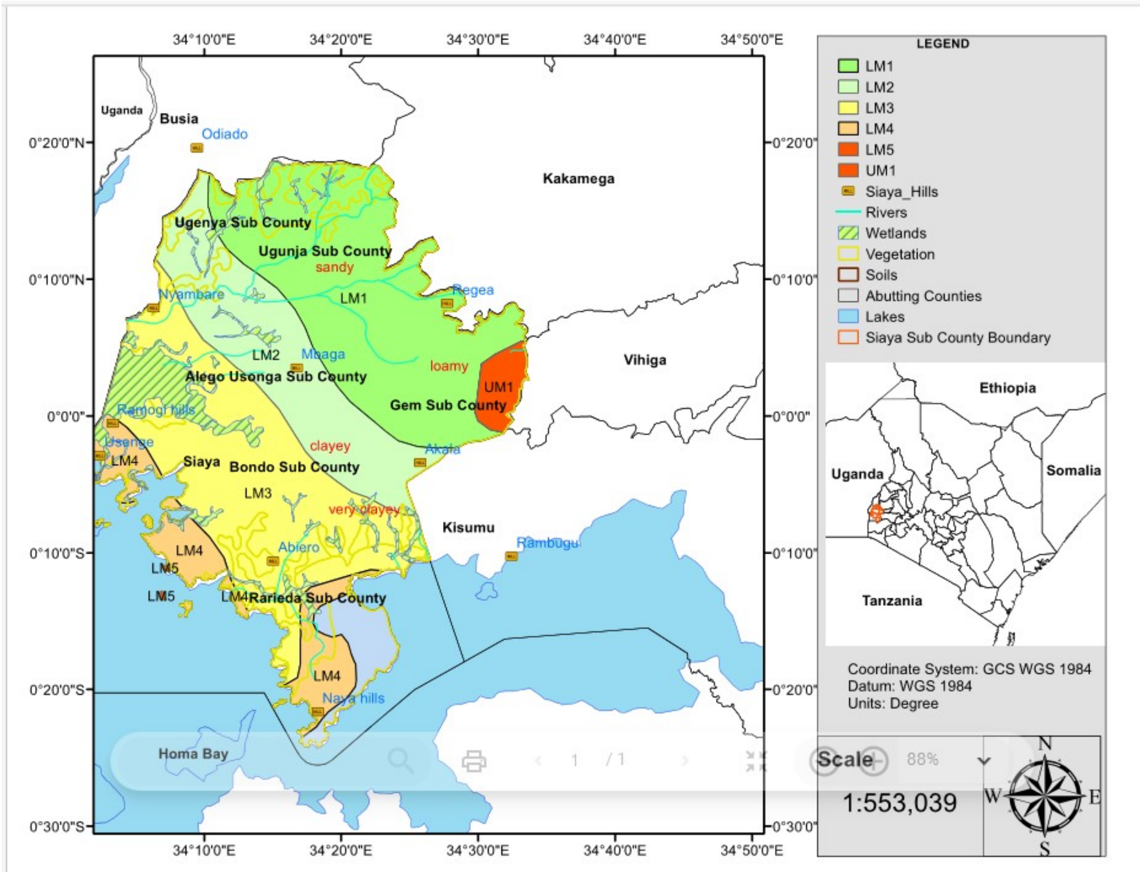

Figure 3. 1: Map of Siaya County indicating different Agro ecological Zones

Source: Researcher (2023)

3.2.1 Administrative boundaries of the study area

Siaya County is divided into six sub counties namely Alego Usonga, Ugenya, Ugunja, Gem, Bondo and Rarieda; thirty wards where Alego Usonga, Bondo and Gem have six wards each and Rarieda, Ugenya and Ugunja have five, four and three wards respectively. However, primary quantitative and secondary climate and food crop yield data for the study were mainly collected in sampled wards as East Yimbo and North Sakwa (Bondo Sub County), North Ugenya and East Ugenya (Ugenya Sub County), and North Alego and Usonga (Alego Usonga Sub County). This is because two sub counties (Ugenya and Bondo) represented high altitude and low altitude areas respectively representing two different climatic conditions while Alego Usonga represented areas that are normally affected by floods in the study area. Siaya County is bordered by Busia County to the North West, Vihiga and Kakamega counties to the North East, Kisumu County to the South East and Homa Bay County across the Winam Gulf to the South (GoK, 2018b).

3.2.2 Population distribution in the study area

Siaya County has a population of 993,183 people with a density of 396.5 persons per Kilometer square (KNBS, 2020). Different sub counties have varying population sizes such as Ugenya having 126,944, Ugunja 108 809, Alego Usonga 218, 199, Gem 187,239, Bondo 183, 564, and Rarieda with 156, 804. Out of the total population, 471,669 are male, 521,496 are female and 18 are intersex. Siaya County has 250,698 households with an average household size of 4 persons. Out of the total households, (41%) 102786 are women headed, (45%) 112,814 are men headed while (14%) 35,098 are children headed. There is a projection of the population size rise in Siaya County to 1,097,141 comprising of 552, 387 male and 544, 755; and 1,136,553 comprising 571,351 male and 565, 202 by 2025 and 2027 respectively (GoK, 2023). There is evidence of possible increase in population growth based on the population projections in Siaya County and increased growth in population influences demand for food. Increased demand for food therefore leads to extensive and intensive usage of the existing arable land to produce more food hence reduces the lands viability over time due to over utilization of the land. Overutilization of land coupled with climate change, food crop production is reduced significantly hence food insecurity (GoK, 2023). This informed the need to test the various disaster risk management approaches related to climate change such as prospective, corrective and that are community based in order to increase agricultural systems resilience for increased food crop production in Siaya County.

3.2.3 Climatic characteristics of the study area

Siaya County experiences three different climates which are; a). Tropical rainforest climate in Wagai, Akala, Kodiaga and Yala (b). Tropical Savanna climate in Bar Olengo, Kadimu, Nyadorera, (c). Tropical Mon-soon climate in Sidindi, Ugunja, Boro and Barkowino with a bimodal rainfall, long rains falling between March to June while short rains September to December. The study area receives an annual rainfall amount of between 800 mm to 2000 mm on the highlands and 800 mm to 1600 mm on the low lands. Daily average temperature varies with altitude rising from 21 degrees Celsius in the North East to about 22.5 degrees Celsius along the shores of Lake Victoria while in the South, it ranges from mean minimum temperature of 16.3 degrees Celsius and mean maximum temperature of 29.1 degrees Celsius (GoK, 2023). According to GoK (2018b), Siaya County is drier in the Southern part towards Bondo and Rarieda Sub Counties hence at times experience droughts and is wetter towards the higher altitudes in the Northern part towards Gem, Ugunja and Ugenya Sub Counties that many times experience floods. In occurrence of either of the weather extremes like floods and droughts, agricultural productivity is reduced hence affecting food crop production availability, access, stability and utilization based on the reduced quality of the available supply (FAO, 2015) hence increasing the risk of food insecurity in Siaya County.

Information on climatic characteristics of the study area formed a concrete background for the climate trends tests in the study area and their relationship with food crop production. Climate trends showing either an increase or decrease in rainfall can be used to indicate potential risks of floods and droughts that may negatively affect the dominant food crops such as maize, beans, cassava, sorghum and sweet potatoes leading to low food crops production. Therefore, this formed the basis for testing the application of the disaster risk management approaches that are climate change related such as corrective and compensatory approaches in mitigating climate change negative impacts on food crop production in Siaya County.

3.2.4 Agro - ecological Zone characteristics of the study area

Siaya County is characterized by a range of agro – ecological zones from Lower Midlands 1 and 5 (LM1 to LM5). According to GoK (2020), there are areas within County and mainly the around the shores of Lake Victoria that are classified as the lower zones which are characterized by semi-humid and semi dry conditions thereby named as Lower Midland zones and these are categorized as;

Lower midland zone 1 (sub-zone LM1): This sub-zone is characterized by long cropping seasons due to cool temperatures, receiving 750-900 mm and 400-500 mm of rainfall in the first and second rainy seasons, respectively. Major crops grown during the long rains (March-April-May) include maize and beans intercrop; sorghum, cassava, groundnuts, cowpeas and sweet potatoes. During the short rains (October-November-December), however, maize and beans intercrop, cowpeas and sweet potatoes are prioritized. Fruit trees such as bananas, pawpaw, passion fruit, mangoes and avocadoes also do well in the subzone. Masiro Katsieno in Ugenya sub-county, Sigomere and Mudhiero in Ugunja sub-county, Yala in Gem Sub County, fall under this sub-zone.

Lower midland zone 2 (sub-zone LM2): This sub-zone is characterized by long cropping seasons only that it receives slightly lower amounts of rainfall of 700-800 mm and 400-500 mm in the first and second rainy seasons, respectively. Maize and beans intercrop, sorghum, cassava, sweet potatoes and sole maize are the main crops grown in both seasons. Similar to LM1, fruit trees such as cooking bananas, pawpaw, passion fruit, mangoes and avocadoes are also do well in the subzone. Sega and Ukwala in Ugenya sub-county, Ugunja centre and Sidindi in Ugunja sub-county, Mutumbu and Wagai in Gem sub-county fall under this sub- zone.

Lower midland zone 3 (sub-zone LM3): Characterized by a medium cropping season and weak short rains, this subzone receives 480-600 mm and 300-400 mm of rainfall in the first and second rainy seasons, respectively. Cotton is the most suitable crop for the subzone, although its cultivation at present is quite limited owing to the near collapse of the industry. Maize and beans intercrop, sorghum, cassava, sole maize, groundnuts, sole beans and sweet potatoes are mainly grown in both seasons, while mangoes are the most common fruit trees. Boro, Siaya town and Uranga in Alego Usonga Sub-County, Rera in Gem sub-county falls under this sub-zone.

Lower midland zone 4 (sub-zone LM4): Characterized by a medium cropping season and weak (short) to very short rains, this sub-zone receives 350-450 mm and 200-300 mm of rainfall in the first and second rainy seasons, respectively. Maize and beans intercrop, sorghum, sole maize and groundnuts are mostly cultivated during the long rains), with maize and beans intercrop and sole maize again being cultivated during the short rains. Similar to LM3, mangoes are common in the subzone. An example of the subzone is

Bondo Town, Mur Malanga and Nyangoma in Alego Usonga sub county, Asembo in Rarieda sub-county.

Lower midland zone 5 (sub-zone LM5): Characterized by a medium cropping season and weak (short) to very short rains, this sub-zone receives 300-400 mm and 200-300 mm of rainfall in the first and second rainy seasons, respectively. Maize and beans intercrop, sorghum, sole maize and groundnuts are mostly cultivated during the long rains. No maize is cultivated during the short rains. Similar to LM4, mangoes are common in the subzone. An example of the subzone is Usenge in Bondo Sub County, Mur Malanga and Madiany in Rarieda sub-county.

It is evident that all ecological zones in Siaya County are of sub humid and humid climatic conditions and are characterized by soil types that support all the dominant food crops as focused in the study. With the changing climate in the study area, all zones are vulnerable to the extreme climatic conditions (floods and drought) hence having negative impact on food crop production. This therefore formed the basis of interrogating the disaster risk management approaches mainly corrective, Compensatory and community based in mitigating the negative impacts to food crop production in Siaya county.

3.2.5 Socio-economic characteristics of the study area

Compared to the national average on socio-economic indicators of 0.56, Siaya County falls behind by 0.46 on most development measures (GoK, 2020). According to GoK (2023), the county has a low Human Development Index (HDI) and struggles with widespread poverty and that is attributed to inadequate resources translating into poor health, nutrition, and education for its people. According to GoK (2022), Unemployment on the other hand, particularly among young adults, is a major issue where most people work in fishing or agriculture, with limited opportunities in formal sectors. It means that as the population keeps growing, competition for these limited jobs will only get worse. However, the percentage of those who can read and write (basic literacy) is 79.75 percent while life expectancy is estimated to be 40 years a staggering 16 years shorter than Kenya's average of 56.6 years (KNBS, 2020). Siaya County also faces other challenges like high population density, water scarcity, and declining food production that contribute to the low human Development Index (GoK, 2023). These attributes to low human development index in Siaya County worsened by climate change negative impacts mainly from drought, floods pests and diseases may reduce the capability of the households to access the suitable disaster risk management approaches hence resulting to rising food insecurity where food crop production is rainfed dependent.

The main economic activities of Siaya County comprise of small-scale agriculture that include crop farming of Maize (*Zea mays*), Sorghum (*Sorghum bicolor*), Millet (*Pennisetum glaucum*), Beans (*Phaseolus vulgaris*), Cassava and sweet potatoes; and indigenous livestock keeping such as the zebu cow, indigenous goats, sheep and chicken. Maize is a staple food crop and therefore over 80% of the residents grow it while 90% of the livestock reared in Siaya are zebu. Cash crop farming is also practiced and these include cultivation of rice, cotton, ground nuts and sugarcane. Some of the emerging crops include soybeans, pam oil, Chilli and grain amarantha (GoK, 2018).

According to GoK (2022), other economic activities include fishing which is practiced in Lake Victoria, Lake Kanyaboli as well as fishing dams and fish ponds. The main fish harvested in Siaya County are Tilapia (*Oreochromis niloticus*) and Nile Perch (*Lates niloticus*), which are consumed locally and also sold to other towns such as Kisumu and Nairobi and exported worldwide where Europe is a major consumer of Nile Perch from Lake Victoria. Other economic activities are based on small scale business within the County like small shop investments and selling of small amounts of farm produce. Given that maize is a rain fed crop which is the staple food in Siaya, and that it is grown by all households, the frequent climate extremes (drought & floods) lead to none or very low yields that cause persistent Food Insecurity. Therefore, the need to employ disaster risk management approaches particularly the corrective and community based to improve food crop production which in turn will lead to food security.

3.2 Research design for the study

The study employed descriptive survey, correlation and evaluation research designs. Descriptive research studies are those studies that are concerned with describing the characteristics of a particular individual, or of a group (Kothari, 2004). Nueman (2000) avers that descriptive research has the capacity to describe present status of phenomena, determine the nature of prevailing circumstances, practices such as the Disaster risk management approaches and sought accurate description of activities as agriculturally based. Correlation Research design on the other hand investigates the relationship between two variables without the researcher manipulating any of the variables. Evaluative design is more oriented towards systematic assessment or approval of the quality and quantity of activities Walingo and Ngaira, 2008). Therefore, the focus on evaluative design is to evaluate and make judgment about its success. This helped in evaluating the disaster risk management approaches on food security in Siaya County.

In this study, descriptive and correlation design were used in objective one, two and three to stablish the socio-economic characteristics which influence disaster risk management approaches; to determine the climate change related disaster risk management approaches; and to determine the relationship between climate trend and food crop production; evaluation design was used to establish the effectiveness of disaster risk management approaches on food security. Additionally, the study utilized both qualitative and quantitative approaches. A summary of research design by specific objectives is as indicated in Table 3.1.

Table 3. 1: Research design by specific objectives

Objective	Measurable Variables/indicators	Research Design
Establish the socio-economic characteristics which influence disaster risk management approaches	• Age, gender, Literacy level, marital status, occupation, family size, land tenure, Income; Prospective, Corrective, Compensatory, Community based DRMA	Descriptive survey and correlational
Determine the disaster risk management approaches that are climate change related	• Prevention activities • Adaptation activities • Risk transfer activities	Descriptive survey and Correlational
Determine the relationship between the climate trends and food crop production	• Annual rainfall amounts • Minimum and maximum temperatures • Dominant food crops Annual Food crop production	Descriptive survey and Correlational
Evaluate the effectiveness of disaster risk management approaches on food crop production	• Trends in Crops yield in relation to the approaches implementation under the changing climate	Correlational and Evaluation

Source: Researcher (2022)

3.2.6 Study Population

The study target population consisted of household heads from the three sub-Counties namely Alego Usonga, Ugenya, and Bondo of Siaya County. The household heads population were the main respondents in acquiring primary data as they are most affected by the extreme climatic conditions with regard to food crop production and also implementers of the risk management approaches. The study comprised of Ministry of Agriculture. Department of Agriculture, irrigation and livestock provided very important information on the yields and general production of both food crops over the years and the climate change related risk management approaches. Kenya Meteorological Department (KMD) formed the source of rainfall data and also gave an in-depth key information on the climate change and their impacts on the agricultural production. County Government of Siaya as the key authority that help in formulation of policies in agricultural production and climate change mitigation which were very key to be incorporated for and in the study. Community Based Agricultural Organizations and Non-Governmental Organizations (NGOs) also formed part of the Key informants as the main supporters of disaster risk management approaches in Siaya County hence provided evidence-based contributions of the risk management for food security as tabled in Table 3.2.

Table 3.2: Study and target population per Sub County

Sub Counties	Quantitative	Qualitative
Bondo	Household heads	CBOs, NGOs officers
Ugenya	Household heads	CBOs, NGOs officers
Alego Usonga	Household heads	KMD, Department of Agriculture, irrigation and livestock, County Government of Siaya, CBOs, NGOs officers

Source: Researcher (2023)

3.3 Sampling procedure and Sample size

In computing household sample size, the research employed the use of Creative Research Systems sample size calculator (2003). In this formula, the researcher uses confidence limit of 95% and accepting a difference of up to 5% of the total population and the formula is as illustrated in equation 3.1.

$$n = \frac{Z^2 p(1 - p)}{d^2} \quad \text{.....................} \quad \text{Eq. 3.1}$$

Where n is the sample size

Z is the confidence limit at 95% which, is 1.96

d is level of significance of + 0.05 or – 0.05

p is the proportion in the target population estimated to have the characteristics being measured which is 0.5. Therefore;

$$n = \frac{1.96^2 * 0.5(1 - 0.5)}{(0.05)^2} = 385 \quad \text{..............Eq. 3.2}$$

The sample size for household survey was 385 household heads

Given the fact that the research required an extensive data collection for a detailed study but can involve the entire population, purposive sampling was employed to sample the five sub counties namely Ugunja, Ugenya, Alego Usonga, Bondo and Rarieda. The sampling was based on the fact that in Siaya County, the northern part composing of Ugenya and Ugunja is wetter receiving between 700 -800 mm and 400-500 mm in the first and second rainy seasons respectively on the higher altitude. The southern part composing of Bondo and Rarieda is drier receiving between 480-600 mm and 300 400 mm in the first and second rainy seasons respectively while the part where Alego Usonga is located experiences a lot of floods caused by the River Nzoia and Yala (GoK, 2018b).

According to Mugenda and Mugenda (2003), 50% response rate is adequate, 60% is good and 70% is above the rated.

The study therefore was conducted in three Sub Counties out of the Six namely Ugenya, Bondo and Alego Usonga. Ugenya Sub County represented the high altitude areas of the northern part of Siaya that receives higher amount of rainfall between 750-900 mm and 400-500 mm of rainfall in the first and second rainy seasons, respectively, Bondo sub County composed of the household respondents from the low altitude areas which are drier and receives low amount of rainfall that is between 300-400 mm and 200-300 mm of rainfall in the first and second rainy seasons, respectively while Alego Usonga with varied climate receiving between 350-450 mm and 200-300 mm of rainfall in the first and second rainy seasons, respectively (GoK, 2023). According to GoK (2018b), the three sub-Counties have more wards from the respective regions than the other three sub counties and that means that they are also highly populated for adequate response hence purposively they were selected for the study. Simple random sampling strategy was used to select wards with regard to the 30% proportionate sampling from the three purposively sampled sub counties as illustrated in Table 3.3.

Table 3. 3: Proportional sampling of the wards from the sampled wards

S/N	Sub counties (Wards)	Total number of wards	30% Sample of wards
1	Bondo	6	2
2	Ugenya	5	2
3	Alego Usonga	6	2
	Total	**14**	**6**

Source: KNBS (2020) and Researcher (2020)

To determine the number of household units per the sampled individual six wards, the study used proportionate sampling. Proportionate sampling provides a researcher with an opportunity to divide a finite population into sub populations and allow usage of random sampling to each subpopulation (Frey, 2020). The sampling strategy was adequate to ensure fair representation of the household head respondents from each and every ward basing on the fact that the wards had different numbers of household units. The sampling is as illustrated in Table 3.3.

$nh = \left(Nh/N \right) n$ …………………………. Equation 3.3

nh = sample size of stratum

Nh = Population size of the stratum

N = Total population size

n = Total sample size

Table 3. 4: Proportional Allocation by wards sampled from the three Sub Counties

Sampled Wards	Total Number of Households (Nh)	Sample size $nh = \left(Nh/N \right) n$
East Yimbo	8, 030	64
North Sakwa	11, 325	91
North Ugenya	8000	64
East Ugenya	8666	70
North Alego	7709	62
Usonga	4232	34
Total	**47962**	**385**

Source: KNBS (2020) and Researcher (2020)

Systematic random sampling strategy was then used in selecting the 385 household heads as the respondents for quantitative data. This approach was based on an interval of 5 participants of the households per the sampled six wards. In-depth interviews were conducted in person with 1 representative from each organization including County administration representative, Ministry of Agriculture, Kenya Meteorological Department, Non-Government Organizations and County disaster management committee totaling to Five (5). These key informants were identified through a combination of simple random and purposive sampling techniques. Appointments were scheduled by telephone with those respondents who were available and willing to speak to the interviewers about disaster risk management approaches in enhancing food security in Siaya County.

The in-depth interviews were conducted using a semi-structured interview guideline. The interviews were recorded with the consent of participants. Note taking from the non-verbal expression, the mood and tone of the participants were observed. Quota sampling was also used to sample FGD participants. All the recordings of each discussion and interviews were transcribed verbally to English and were reviewed for accuracy with the consent of the interviewees.

3.4 Data Collection Methods

This section gives an account of the instruments that were used in collecting data from the field by the researcher which is summarized in Table 3.5

Table 3. 2: Summary of Study Population, Sampling methods, Sample Size and Data Collection Tools for Siaya County, Kenya

Study Population unit	Sampling method	Sample size	Data Collection tool	Appendix Number
Household heads	Multistage/ Proportionate	385	Questionnaire	II
Admin. Rep.	Purposive	1	Interview guide	III
County Ministry of Agriculture	Purposive	1	Interview guide	IV
KMD officer	Purposive	1	Interview guide	V
County Disaster Management officer	Purposive	1	Interview guide	VI
NGOs officer	Purposive	1	Interview guide	VII
4 Focus Discussion Groups (Each 10 participants)	Quota	4	FGD Guide	VIII

Source: Researcher (2020)

The researcher collected both primary and secondary data.

3.4.1 Primary data collection

In reference to Table 3.5, Primary data were collected using questionnaire (Appendix II) with both closed and open-ended questions to source data from household heads. In-depth face to face interviews were done using interview guides for Key informants. KIIs were used to seek clarity given the fact that questionnaires may not provide ground for further probing for the study. The interview guides were used to source information from the County administration representative (Appendix III) on government approaches related to risk management of extreme climatic conditions for food security, County Department of Agriculture officers (Appendix IV) on the food crop production and yields in relation to different climatic trends, Kenya Meteorological Department officers (Appendix V) on the climate trends, County disaster management officers (Appendix VI) on the climate related disasters and their impacts on food crops; and existing NGOs working with the community to improve food security through climate change mitigation approaches (Appendix VII). Focus group discussions (FGDs) guides composed of different gender and in groups of 8 participants (Appendix VIII) were used for the study.

The questions in the tools were centered on different topics as climate change experiences, disaster risk management approaches applied by the households in mitigating negative impacts of climate change and the food crop yields in relation to the disaster risk management approaches application by household heads. The tools were used to investigate which were the most preferred climate related disaster risk management approaches by the participants in the occurrence of climate change to prevent, reduce and in compensation of the climate change negative impacts? what were the relationship between climate trends and food crop production? and how effective the various disaster risk management approaches were in increasing food crop production for food security in Siaya County?

3.4.2 Secondary data

This study acquired secondary data on annual rainfall and minimum/maximum temperature from Kenya Meteorological Department stations in Siaya County and supplemented these by additional data from the main KMD headquarters in Nairobi for the incomplete data to fill the gap. Additionally, River gauge data for Lower Nzoia and River Yala at the Dominion farm for flooding analysis was sourced from the Regional flood management offices with the Water Resource Authority (WRA). Lastly, Annual food crop yield was acquired from the Department of Agriculture, irrigation, food, livestock and fisheries of Siaya County. Impacts of extreme climatic changes (floods and droughts) on agriculture; and the disaster risk management approaches related to climate change to reduce the impacts of floods and drought in enhancing sustainable food security in Siaya County were collected from the various climate change, disaster risk management and food security journals and reports.

3.5 Validity and reliability of research instruments

3.5.1 Validity

Validity of research entails factual information and accuracy of the information presented by a study (Schroder *et al*., 2003). Joppe (2000) further contends that validity of research is about the truthfulness of the research results and whether the research actually measures what it is intended to measure in the first place. Validity of research instrument can be determined through expert examination (Cohen & Marion 1994). To ensure the validity of the data collection instruments, all the instruments that were utilized during the study were presented to experts at the department of Disaster Management and Sustainable Development at Masinde Muliro University of Science and Technology that determined the accuracy and usage of these instruments in answering the research questions and proving truthful information.

In determining statistical proof, Content Validity Index CVI was used to determine the validity of all the three instruments. This tested whether the instruments had appropriate sample of items for the construct subjected to measurement. The CVI is commonly used because it is easy to compute, understand and focuses on agreement of relevance. Polit *et al.* (2007) observes that CVI on consensus rather than consistency and provides both item and scale information. The following CVI formula was used to calculate the content validity for questionnaires, interview guides and Focus group Discussions guides.

$$CVI = \frac{n}{N} \quad \text{………………………. Equation 3.4}$$

Where n is the number of items that were declared valid and N is the total number of items. Therefore, data instruments are considered to be valid if the calculated CVI is above 0.7 (Polit *et al.*, 2007).

Table 3. 3: Determination of the Content Validity Index for data collection

Instrument	Section	Valid item	Invalid item	Total
Household Questionnaire	A	6	1	7
	B	7	2	9
	C	3	0	3
	D	4	1	5
	Total	**20**	**4**	**24**
Interview guides	A	10	2	12
	B	2	1	3
	C	2	1	3
	Total	**14**	**4**	**18**
FGD Guide	A	4	0	4
	B	3	1	4
	C	4	0	4
	Total	**11**	**0**	**12**

Source: Pilot Survey results 2022

HHQ CVI = $\frac{20}{24} = 0.8333$ **CVI (FGD) =** $\frac{11}{12} = 0.9166$

CVI (IG) = $\frac{14}{18} = 0.7777$

Data instruments are considered to be valid if the calculated CVI is above 0.7 (Polit *et al.*, 2007). In this regard, household questionnaire, interview guides and Focus Group

Discussion guides were valid at 0.8333, 0.777 and 0.9166 respectively. Therefore, all the data collection instruments were all valid as recommended.

3.5.2 Reliability

A pilot study was conducted to examine the instruments and approaches set for the study in generation of information to meet objectives of the study. This helped the researcher to identify areas of concern in the questionnaire in terms of clarity with the questions. This was in keen observation of the comments and trends of respondents that indicated whether the questions were well understood. The piloting helped in reducing vagueness and improved understanding of the questions for precise responses.

The instruments were tested on 39 household heads based on the 10% of the sample size (385) by Connelly (2008) in Karachuonyo Sub County in Homa Bay County. The Sub County also exhibits the same climatic characteristics and food insecurity concerns as those sampled for the main study. The respondents were sampled in line with the procedure described under sub section 3.5 which included purposive sampling for Key officials from both the County disaster management, agriculture and meteorological management.

To measure the reliability, Alpha (Cronbach, 1975) technique was employed. In this approach, a score that was obtained in one item was correlated with scores obtained from other items in the instrument; Cronbach's Coefficient Alpha was computed to determine how items correlated among themselves. Cronbach's Alpha is a general form of the Kunder- Richardson (K-R) 20 formulae. The use of K-R 20 formula in assessing internal consistency of an instrument is based on the split – half reliabilities of data from all possible halves of the instrument. Use of K-R 20 formula reduces the time required to compute a reliability coefficient in other methods. Its application also results in a more conservative estimate of reliability; the estimated coefficient of reliability of data is lower. The K-R formula is as follows:

$$\frac{KR_{20} = (K)(s^2 - \sum s^2)}{(S^2)(K - 1)}$$

……………………………. Equation 3.5

Where;

$KR_{20=}$ Reliability Coefficient of internal consistency

K= Number of items used to measure the concept

S^2= Variance of all scores

s^2= Variance of individual items

A high coefficient implies that items correlate highly among themselves meaning there is consistency among the items in measuring the concept of interest. This is referred to as homogeneity of data whereby the researcher can confidently depend on the information gathered through various sources of data adopted for the study. Alpha (Cronbach, 1975) is a model of internal consistency based on the average inter- item correlation. The instrument was divided into two parts using even and odd numbers. A large value of alpha (preferably greater than 0.6) indicates high level of consistence of the instruments in measuring the variables. The co-efficient of internal consistency above at 0.6 is considered good. The instrument was then adjusted on the basis of the findings of the pilot test and the final version developed thereafter that attained the correlation value of 0.7.

3.6 Data processing, analysis and presentation

The final stage of research entailed manipulating the collected data for the purpose of drawing conclusions to address the study problem. Both quantitative and qualitative techniques were used to process, analyze and present the data.

3.6.1 Data processing and organizing

The study used continuous data processing so as to minimize the time interval between completion of data collection and data entry. Data processing involved coding data, digitization of coded data, cleaning, organizing entry into the SPSS software, and identifying non-compliance in the generated data from face-to-face interviews.

3.6.2 Data analysis methods

Collected descriptive/qualitative data were categorized into specific themes and sub themes. Descriptive statistics were used in organizing and summarizing the data collected. The analyzed data were presented using frequency distribution percentages and tables, descriptive statistics and discussions. All the quantitative data from the questionnaires were analyzed using the Statistical Package for Social Scientists (SPSS) version 20.0 for inferential statistics.

3.6.2.1 Analysis of climate trends in Siaya County

a) Analysis of Rainfall and Temperature trends

Rainfall and Temperature trends was done using Mann-Kendall (M-K) software. The Mann-Kendall test is a statistical method without fixed parameters that is extensively employed for analyzing trends within climatic and hydrological time series information. The test's underlying principle involves comparing a null hypothesis (H0) suggesting the absence of a trend (with data being self-reliant and randomly arranged) against an alternative hypothesis (H1) positing the existence of a trend. The computation of the M-K statistic proceeds as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(xj - xk) \quad \text{……. Equation 3.6}$$

The trend test is applied to a time series X k, which is ranked from k = 1,2, 3…,n−1, which is ranked from j = i + 1,i + 2,i + 3…..n. Each of the data points x j is taken as a reference point,

Sgn (xj – xk) = 1 if xj – xk > 0
= 0 if xj – xk = 0
= -1 if xj – xk < 0

This particular test has been calculated using XLSTAT 2017 software. A very high positive value of S is an indicator of an increasing trend and a very low negative value indicates a decreasing trend. The presence of a statistically significant trend is evaluated using Z value

b) Drought Trends Analysis

The collected Rainfall data (1991 – 2021) was organized systematically and be analyzed using a Standardized Precipitation Index (SPI) to determine the drought anomalies and trends in Siaya County. In this method, the data was categorized based on the main seasons as DJF, MAM, JJA and SON in the region. Therefore, to analyze the drought trends, SPI was computed from the mean and standard deviations of the annual rainfall amount. (Equation 3.6). Where, the severity of drought is measured by value of the SPI if the computed index is negative the median precipitation = 1.00 the situation will be treated as normal, > 1.00 the situation will be treated as better than normal while < 1.00

the situation will be treated as worse. This may also be categorized as moderate, severe and extreme drought.

$H(x) = q + (1 - q)G(x)$ ………Equation 3.7

Where, q is the probability of zero, calculated from the frequency of zero precipitation observations in the time series; G(x) is the cumulative probability calculated from the Gamma distribution for non-zero observations.

c) Flood Trends Analysis

Floods were analyzed based on the annual rainfall data for the period under study (1991 – 2021) was organized and computed through a Rainbow software for normal distribution method as a standard practice to estimate the annual exceedance probability (Raes *et al*., 2006). Through this method, the study was in a position to determine the probability of exceedance and frequency of the flood occurrences in Siaya County (Equation 3.6). Secondly, River gauge data was analyzed using River flow duration curve where Q- discharge flow was calculated for Q 50 as flood flow, Q 80 as normal flow and Q 95 as environmental flow. In addition, qualitative data which was obtained through key informant interviews, Focus Group Discussions and observation checklists was processed and analyzed following three steps. In the first step, data was organized and summarized in line with the thematic areas. The second step involved description of the summary sheets to produce preliminary report. The third step involved systematic analysis and interpretation of the preliminary report, which was then integrated with the quantitative data in the final report. Table 3.7 shows the summary of the data analysis procedure in relation to specific objectives of the study.

$P = \frac{m}{n+1}$ ……………Equation 3.8

Probability of exceedance as P, n as number of data points, m as rank of events

Table 3. 4: Summary of data analysis by objectives

	Specific objectives	Variables	Data analysis
i	Establish the socio-economic characteristics which influence disaster risk management approaches	Age, gender, Literacy level, marital status, occupation, family size, land tenure; Prospective, Corrective, Compensatory, Community based DRMA	Descriptive statistics and correlation
ii	Determine the disaster risk management approaches related to climate change	Prevention activities Adaptation activities Risk transfer activities	Descriptive statistics and inferential statistics
iii	Determine the relationship between climate trends and food crop production	Annual rainfall amounts; minimum and maximum temperatures; River gauge data and Crop yield	Time series (Rainfall and Temperature) Inferential Statistics, Mann Kendal and SPI
iv	Evaluate the effectiveness of disaster risk management approaches on food security	Trends in Crop yields in relation to disaster risk management approaches implementation	Descriptive Statistics, and Inferential Statistics

Source: Researcher, (2021)

d). Land use land cover mapping method

Methodology adopted for the development of land cover land use map was done using data model on land use/ land cover on 1:10,000 scales. The data model was developed based on certain parameters namely, base line data, Cadastral maps, Central Survey Maps, SOI top sheet and Satellite data and ground truth data. The process encompassed, a). Acquisition of satellite data from NRSC in soft copy, b) Processing of satellite data so as to make data free from all the errors caused by atmosphere, geometry, and radiometry during the acquisition of data, c) Geo-referencing of high resolution IRS P6 LISS IV-MX (5.8mt resolution) satellite data was then done by using geo-referenced toposheets and

GCPs collected from field survey, d) After placing GCPs, input file and reference file were saved and after that, re-sampling of satellite data was carried out. This procedure was repeated for every scene of concerned path and rows of satellite of the project, e) Overlaying of the geo-referenced satellite data on respective toposheets was done to check whether the features were perfectly matched or not with toposheets f) Geo-referenced LISS- IV- MX (5.8 mt), and CARTOSAT-1 (2.5 mt) images were merged to get high resolution data (i.e. 2.6 Spatial resolution) with multispectral, g) Mosaic process of these scenes were done to make the image to show continuous terrain of project area, and h) ArcGIS 10.6 software was used to fix 1:10,000 Scales. In the ArcGIS software without moving the scale, visible features in 1:10,000 scale was then digitized to output the map.

3.6.3 Data presentation

The analyzed data is presented in form of line graphs, charts, bar graphs, tables and in discussions.

3.7 Assumptions of the study

The study was done based on the following assumptions:

i). There was climate change in Siaya county

ii) There were impacts of floods and drought to food crop production in Siaya County

iii) There was implementation of disaster risk management approaches related to climate change in Siaya County.

3.8 Limitations of the study

During the study, the following limitations alongside their solutions were observed:

The study had proposed to use Compound Drought Index analysis for drought. However, due to lack of certain indicators such as the Vegetation health and soil moisture, the study adopted Standardized Precipitation Index (SPI) to analyze drought indices.

There was insufficient data with regard to the monthly minimum and Maximum Temperature from the study area meteorological station. However, the study managed to acquire annual minimum and Maximum data from the neighboring stations since the region's climatic characteristics are homogeneous.

3.9 Ethical Considerations

The researcher first sought for permission to conduct the study from the Directorate of Post graduate Studies research committee of Masinde Muliro University of Science and Technology (MMUST) (Appendix IV). This facilitated the acquisition of a research permit from the National Council of Science and Technology (NACOSTI) (Appendix V). Additionally, this study also obtained authorization to conduct the study in Siaya County from both the County director of Education (Appendix VI) and the County Commissioner of Siaya (Appendix VII). During data collection, there was informed consent for the informant and participants to provide information and participate in the execution of the research activities. In addition, the respondents had to adhere to freedom of expression of ideas and consensus during data collection. The information obtained was treated with confidentiality and will be used for academic purposes only. The respondents had prior information of their right to withdraw at any stage of the engagement and the right to demand explanation on the use of the information they intend provide to the researchers.

CHAPTER FOUR

SOCIO-ECONOMIC CHARACTERISTICS INFLUENCING DISASTER RISK MANAGEMENT APPROACHES FOR FOOD CROP PRODUCTION IN SIAYA COUNTY, KENYA

4.1 Introduction

This chapter presents and discusses results from analyzed data derived from; a). Socio-economic characteristics of the respondents in the study area which included; demographics (age, sex, marital status, and family size), education level, income, occupation and land tenure system; and their relationship with the disaster risk management approaches in the study area.

4.2 Socio-economic characteristics of households and the disaster risk management approaches for food crop production in Siaya County

This section focused on the demographic characteristics of the respondents mainly on age, gender, marital status, education level, income levels, occupation, years of residence, family size and the type of land tenure system. This was with the focus on their influence on adoption of various disaster risk management approaches first as prospective with activities (greenhouse gas reduction, land use planning, agro-forestry, and early warning information). Secondly the study focused on their influence as corrective approach with activities (soil and water management, drought tolerant crops, crop diversification, improved storage facilities, and flood management). The third focused on compensatory approach with activities (contingency funds, crop insurance, safety nets, and agricultural subsidies), while the fourth on community-based approach with activities (prediction of hazards, planning of risks reduction, implementation of risk reduction, monitoring of implementation of risk reduction strategies and risk analysis) adoption in Siaya County.

4.2.1 Age of the household respondents and the disaster risk management approaches for food crop production in the study area

The study sought to establish the age of the respondents that were involved in the study and the results are as presented in Figure 4.1. Analysis revealed that 2% (8) of the household heads were aged between 18 – 22, 5% (19) were between 23 – 27, 10% (39) were between 28 – 32, 18% (69) were between 33 – 37, 32% (123) were between 38 – 42, 13% (50) were between 43 – 47, 11% (42) were between 48 – 52, 5% (19) were between 53 – 57, 3% (12) were between 58 – 62, 1% (4) were between 63 – 67 while none of the household respondents were above 68 years old. The analysis therefore indicates that the majority of the respondents in terms of age were between 38 – 42 years while the least were between 63 – 67 years old in Siaya County.

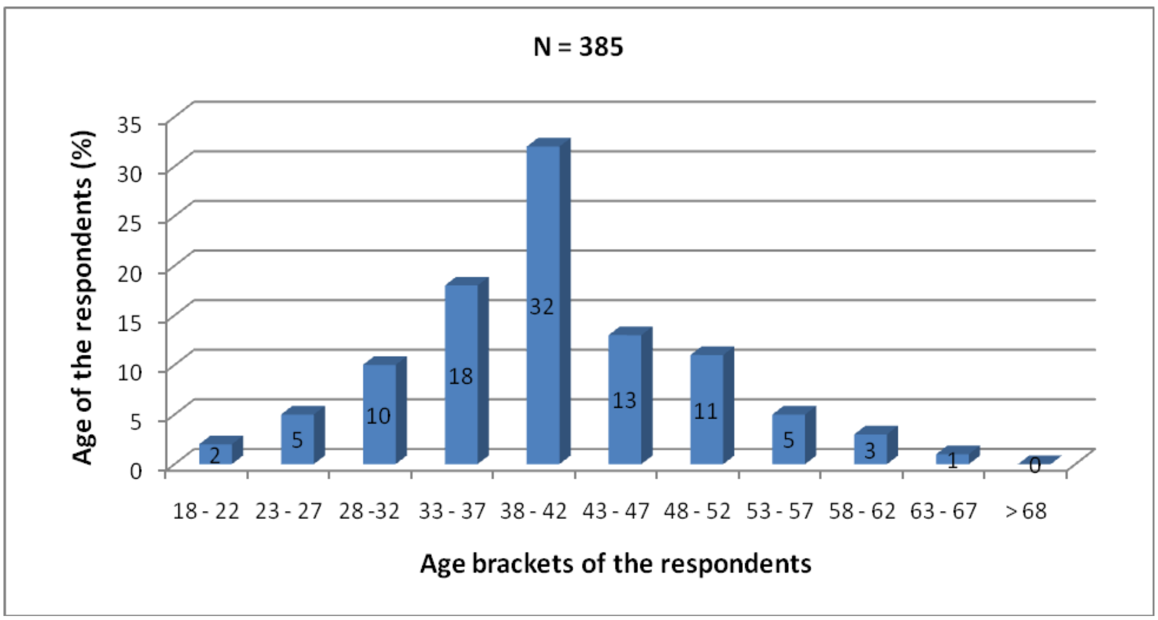

Figure 4.1: Age of the household respondents in Siaya County

Source: Field data (2022)

The study established that the majority (32%) of the respondents were middle aged household heads. It resonates with Odunga (2019) findings on food production and food security in Siaya County where the majority of the sampled small scale farmers were between 30 – 49 years of age. This was also in agreement with Wetende *et al*., (2018) on perception of small scale farmers on climate varriability in Siaya where majority of the respondents were aged from 30 to 74 years old with majority being the middle age in Siaya County.

In an effort to establish the relationship between age and disaster risk management approaches for food crop production in the study area, correlation analysis was conducted and the results are as presented in Table 4.1 . The results show a correlation coeficient of 0.695 indicating a strong positive relationship between age and prospective disaster risk management approach, -0.103 showing a weak negative relationship between age and corrective approach, 0.509 as positive moderate relationship between age and compensatory approach, and 0.592 positive moderate relationship between age and community based disaster risk management approach. Generally, a correlation coeficient of 0.594 indicating a moderately positive relationship between age and cummulative disaster risk management approaches such as prospective, corrective, compensatory and community based as applied by the respondents with statistical significance of 0.045 ($P<0.05$).

Table 4. 1: Relationship between age and Disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Age	Pearson Correlation	.695	-.103*	.509	.592	.594
	Sig. (2-tailed)	.026	.043	.250	.070	.045
	N	385	385	385	385	385

Source: Field data (2023)

Findings show that as the ages of the respondents increase, there is an increased involvement in the practice of various disaster risk management approaches to mitigate the climate change negative impact for improved food crop production. This was found to vary from one disaster risk management approach to the other hence age being a factor that influence use of various approaches however, this showed a low statistical significance in their application in the study area. The study established that the most involved farmers in food crop production in Siaya County were members of the community who still had enough physical and economic energy such as the middle aged.

According to Ng'ang'a *et al*., (2020) and Mogaka *et al*., (2021) social differentiation such as age of individuals is a factor in adoption of approaches used in mitigating climate change in the ASAL regions of Kenya. However, Simeon *et al*., (2018) revealed that low food crop production was highest among the young population between 20 – 35. This therefore attests that the young could be the majority in food crop production but are not highly involved in the practice of disaster risk management approaches to mitigate the negative impacts of climate change hence low food crop production in Siaya County.

4.2.2: Gender of the household respondents and the disaster risk management approaches for food crop production in Siaya County

The study sampled 385 respondents from the total household heads in the study area and the results were as presented in Figure 4.2. It was established that 42.6% (164) of the respondents were male while 57.4% (221) were female in the study area. It was therefore concluded that the majority of the respondents in the study area were female household heads.

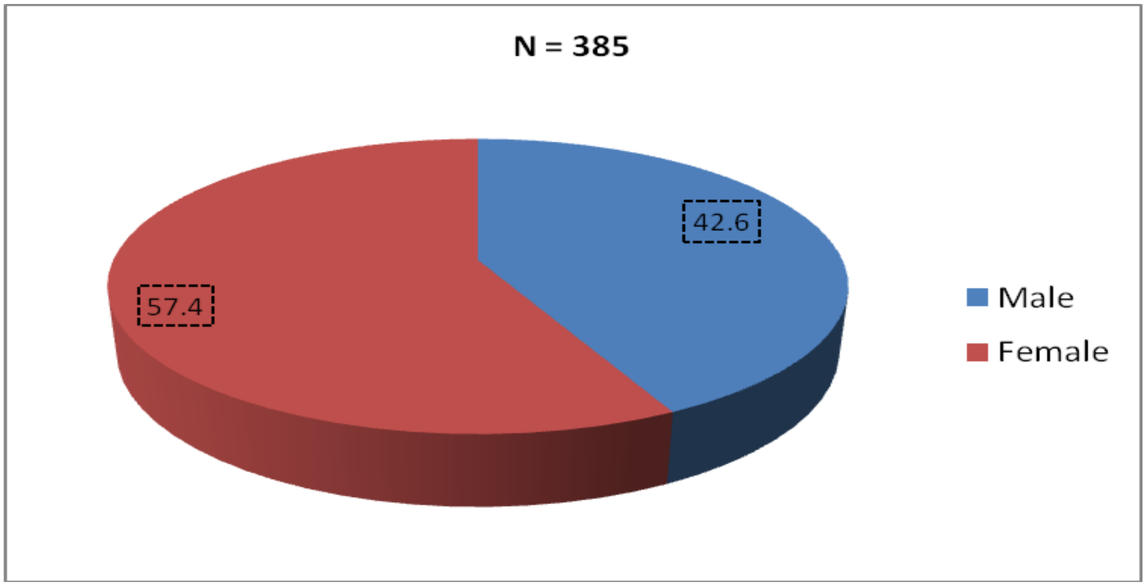

Figure 4.2: Gender of the household head respondents in Siaya County

Source: Field data (2022)

The finding agreed with Wetende *et al*., (2018) on perception of small-scale farmers on climate variability, however contradicted by Odinga *et al.*, (2022) where the majority was male at 56.2% against female at 43.8% respondents for a study on the quality of various food crops in Siaya County. Therefore, the study established that gender involvement in disaster risk management towards food crop production may vary from one study to another in Siaya County.

To establish the relationship between gender and the disaster risk management approaches applied for food crop production in Siaya County, the study conducted a correlation analysis and the results are as shown in Table 4.2. The results show a correlation coefficient of -0.24 indicating a weak negative relationship between gender and prospective approach, 0.29 indicating a weak positive relationship between gender and corrective approach, 0.140 showing a very weak relationship between gender and compensatory approach and -0.018 showing a negatively very weak relationship between gender and community-based approach. Cumulatively, a correlation coefficient value of 0.610 indicated a strong positive relationship which was statistically significant 0.023, $p < 0.05$.

Table 4. 2: Relationship between gender and disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Gender	Pearson Correlation	-.024	.029	.140**	-.018	. 610
	Sig. (2-tailed)	.634	.566	.006	.724	.023
	N	385	385	385	385	385

Source: Field data (2023)

The results therefore show that there was a significant variation in the usage of the various disaster risk management approaches based on variation on gender of the household heads for food crop production in the study area. Studies have shown that women play a greater role majorly in subsistence agriculture than men. According to Mehra and Rojas (2008), women make an essential contribution in rural agriculture and specifically in food crop production in most developing countries. Previous studies have also shown that women produce between 60 – 80% of the food crop production in most developing countries like Kenya. It therefore means that by default, the female gender is highly involved in the various disaster risk management approaches than the male counterparts in prevention, reduction and in risk transfer in the event of climate change negative impact on the food crops. In most situations the question of women involvement in the food crop production is coupled by their level of participation in the disaster risk management approaches in enhancing food crop resilience and adaptation strategies to climate changes (Mamkwe, 2016). However, Kiriti-Ng'ang'a (2015) asserts that women do not produce food separately from men but with contribution from both men and women in a collaborative process hence possible equal participation of both gender in all the disaster risk management approaches in mitigating the negative impacts of climate change for food crops production.

4.2.3 Marital status of the household respondents and the disaster risk management approaches for food crop production in Siaya County

The study sought to establish the marital status of the household respondents in Siaya County and how this influences their practices in disaster risk management approaches for food crop production in Siaya County. The results in Figure 4.3 indicate that 9% (35) of the respondents were single, 46.7% (177) were married, and 37.3% (146) were widowed while 7% (27) were others such as the divorced and separated. Therefore, the study established that the majority of the respondents were married followed by the widowed then the singles and lastly either the divorced or separated.

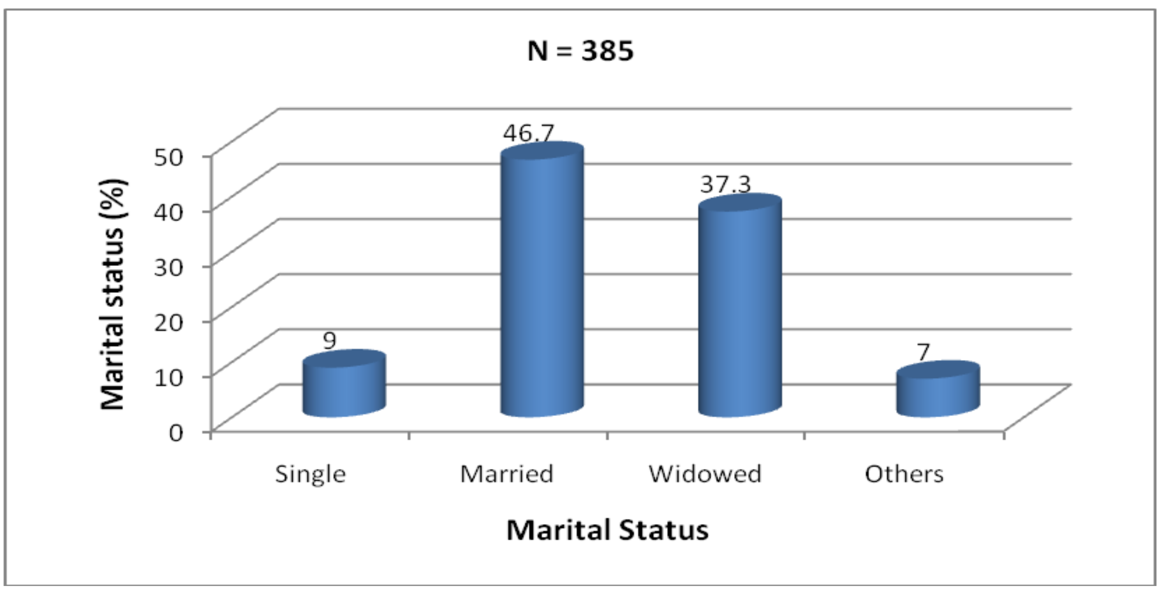

Figure 4.3: Marital status of the household respondents in Siaya County

Source: Field data (2023)

On the question on whether the disaster risk management approaches practices are linked to ones marital status is of importance to this study. The study therefore sought to establish the relationship between marital status of the household respondents and the disaster risk management approaches practices in Siaya County. A correlation analysis was done and a coefficient of 0.734 showing a strong positive relationship between marital status and prospective approach, 0.91 showing a strong positive relationship between marital status and corrective approach, -0.854 showing a strong negative relationship between marital status of a household head and compensatory approach and -0.11 showing a weak negative relationship between household heads marital status and community based disaser risk management approach while cummulatively, a correlation coefficient of 0.899 was generated indicating a very strong positive relationship which was significant at 0.008, $p<0.05$. This shows that there is significant association between household heads marital status and and the practice of the various disaster risk management approaches.

Table 4.3: Relationship between Marital status and the disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Marital Status	Pearson Correlation	.734	.910	-.854	-.011	.899
	Sig. (2-tailed)	.503	. 047	.029	.834	.008
	N	385	385	385	385	385

Source: Field data (2023)

The results show that varriation in marital status influenced the variation in the levels and type of disaster risk management approach practiced in mitigating negative impacts of climate change in Siaya County in improving food crop production. According to Karla *et al*., (2007), low food crop production may be as a result of limited access to resources such as means of production like land and access to financial reasources. In African setting and specifically in rural areas like Siaya County, resources are mainly owned by men as opposed to women ownership. It means that in the likely event that the man ceases to exist then women also lose ownership either through cultural vices. While women contribute to over 60% of small scale food crop production, there are high chances that those not married may not actively participate in farming due to lack of or may experience reduced investment on disaster risk management approaches that are expected to build food crop production systems resilience due to their lack of accessibility to land or financial credits for crop farming.

The study therefore concludes that married couples have a higher potential of increasing food crop production unlike the unmarried such as the single, the divorced and widowed who may either have little or no resources or have little or no access to other financial reasources to help them invest in longterm disaster risk management approaches for increased food crop production. From the Focus Goup Discussion, it was established that Siaya County just like majority of other parts of Africa is a patriacal society. The participants expalained that, the means of production such as land belonged to the men and many times when the men die then the land ownership is taken from the widows. In addition, the failure by women to own land deprives them the opportunity to benefit from loans as land is the main aset for majority of the households in Siaya County.

4.2.4: Education levels of household respondents and the disaster risk management approaches for food crop production in Siaya County

Results from the analyzed data (N=385) for the education levels of the individual household respondents in Figure 4.4 indicate that 14.4% (55) of the respondents had attained their highest education levels as University, 32% (123) had tertiary, 43.6% (168) had secondary education while 10% (39) had primary education. The results show that majority of the respondents had attained at least secondary education and a bove while the rest of the respondents had basic education. The results agree with Odunga (2019) on food production and food security of smallholder farmers supported by the County government of Siaya that the majority of the respondents had secondary education however 8.6% had no basic education in Siaya County.

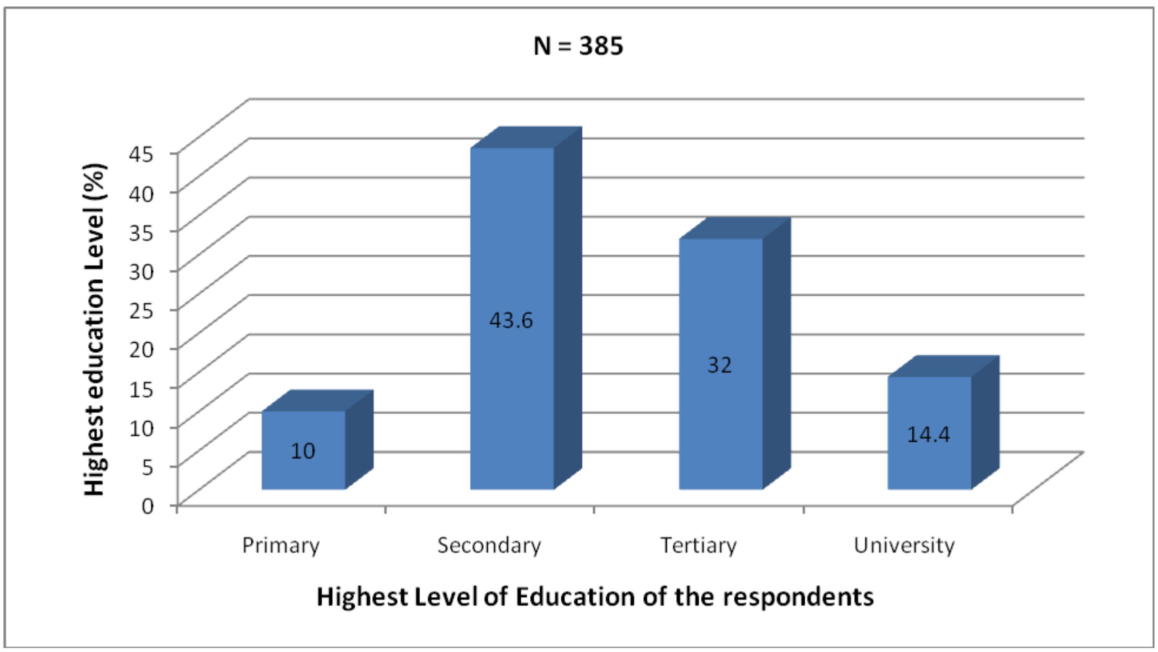

Figure 4.4: Education levels of the household respondents in Siaya County

Source: Field data (2023)

In an attempt to establish the association between education level and the practice of the various disaster risk management approaches for food crop production in the study area. A correlation analysis was done and results in Table 4.4 show a correlation coefficient of 0.544 showing positive moderate relationship between literacy level of household heads and prospective approach practice, 0.712 showing a strong positive relationship between literacy level of household heads and corrective approach practices, -0.037 showing a weak negative relationship between literacy level of household heads and compensatory approach practices, and -0.072 showing a very weak negative relationship between literacy level of household heads and the practice of community based disaster risk management approach. A cumulative correlation analysis between education level and the disaster risk management approaches displayed a correlation 0.072 which was not statistically significance of 0.697, $p > 0.05$.

Table 4. 4: Relationship between education level and the disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Education Level	Pearson Correlation	.544	.712	-.037	-.071	.072
	Sig. (2-tailed)	.393	.819	.468	.166	.697
	N	385	385	385	385	385

Source: Field data (2023)

The study therefore established that practice of the various disaster risk management approaches have no association and are not influenced by education levels among the households in Siaya County. Mogaka *et al*., (2021), in Western Kenya where Siaya County was sampled for the study, education level had an influence on climate smart agriculture practices adoption which is a corrective approach towards climate change mitigation. It is believed that individuals with higher education are in a position to make informed and better decisions relating to food crop loss risks reduction as opposed to ones with lower education levels. This agrees with Ihemezie *et al.*, (2018) with general considerations that with their high level of education, they have better access to information and understanding of the available knowledge and technologies in disaster risk management and their application in mitigating and adapting to climate change for food crop production than those who never had the opportunity for higher education.

According to Bashir and Schilizzi (2013), education influences food crop production through utilization of the acquired agricultural risk management practices Additionally, education is also associated with better income through better employment opportunities that is expected to have an effect on affordability of the critical technologies for mitigating the negative impacts of climate change among populations (Gebre 2012).

4.2.5: Occupation of the household heads respondents and disaster risk management approaches for food crop production in Siaya County

The results on occupation of the household heads are as indicated in Figure 4.5. The results show that 58% (223) of the respondents are highly engaged in farming, 24.8% (95) are mainly involved in small business such as in retail shops, hawking and motorcycle business, and 15.2% (59) are in fishing, while the rest of the respondents were in other occupations such as formal employment as their main sources of livelihoods. It is therefore concluded that the majority of the households are involved in farming in Siaya County.

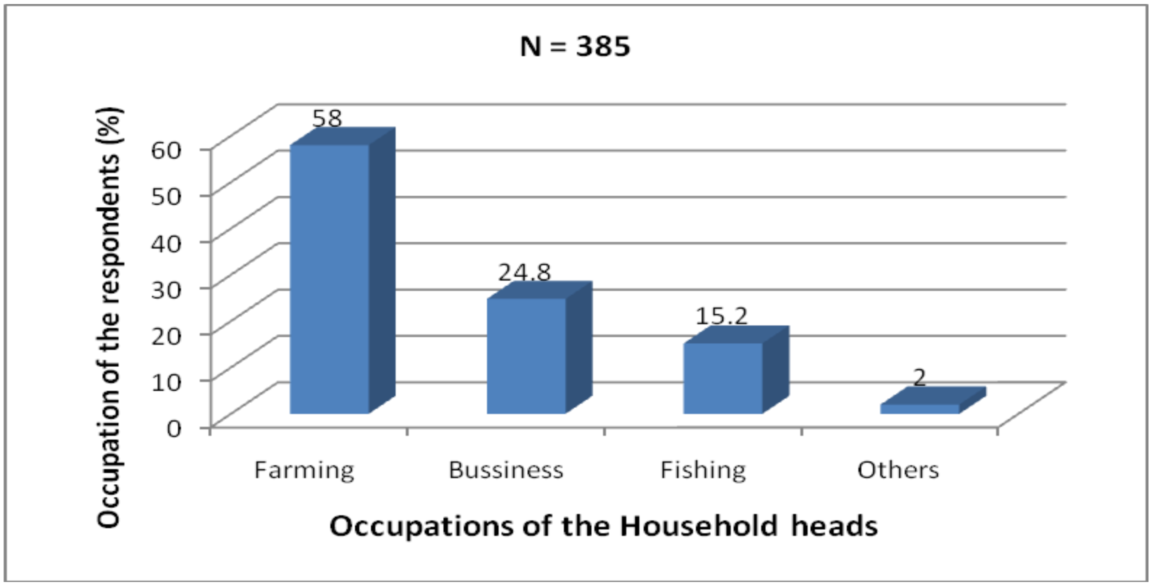

Figure 4.5: Occupation of the household head respondents in Siaya County

Source: Field data (2023)

It was established that the majority in farming are self-employed in their farms and totally depended on the farm produce for food. Those involved in fishing also use the fish both for subsistence while the rest are engaged in small businesses such retailing, motorbike operations and vendor businesses. Lastly, the other populations of the household heads were of formal employment majority being civil servants such as teachers. To test if there existed any association between occupation of the household heads and disaster risk management approach practices for food crop production, a correlation analysis was conducted and the results are as shown in Table 4.5.

The results show a correlation coefficient of -0.061 showing a weak negative relationship between the occupations of the household heads and prospective approach, 0.650 showing a strong positive relationship between household heads occupation and corrective approach, -0.057 showing a weak negative relationship between household heads occupation and compensatory approach, and -0.046 showing a weak negative relationship between household heads occupation and community based disaster risk management approach. Cumulatively, a correlation coefficient of 0.537 showed a moderate positive relationship between household head's occupation and the various disaster risk management approaches which was significant at 0.046, $p < 0.05$.

Table 4. 5: Relationship between occupation and disaster risk management for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Occupation	Pearson Correlation	-.061	. 650	-.057	-.046	.537
	Sig. (2-tailed)	.233	. 024	.267	.366	.046
	N	385	385	385	385	385

Source: Field data (2023)

It therefore means that the variations in occupations of the respondent influenced positively the different types of disaster risk management approaches by the respondents for food crop production in the study area. Majority (58%) were involved in farming explaining the number of household occupation that was more vulnerable to climatic risks hence reducing food crop production. While it is expected that other sources of income from other occupations such as from formal employment may be used to afford best agricultural technologies that may reduce the risks from climate change negative impacts just a minority 42% who were not in farming hence confirming the low food crop production in Siaya County. Mose and Mukami (2020) argues that household heads who are formally employed are able to alleviate their food crisis by supplementing production of food crops by investing in various disaster risk management approaches from their earnings from formal employment which is contrary to the situation in Siaya with minority having formal employment, hence low food crop production.

4.2.6: Years of residence of the household head respondents and disaster risk management approaches for food crop production in Siaya County

The study sought to establish the number of years the respondents had lived in the study area. The results in Figure 4.6 show that majority of the respondents 49% (189) had lived within the study area for over 30 years, 25% (96) had resided there for at least between 24 – 29 years, 13% (50) for at least 18 – 23, 9% (35) for between 12 – 17 years, 4% (15) had lived for at least between 6 – 11 years then none of the household respondents had lived in the study area for less than 5years.

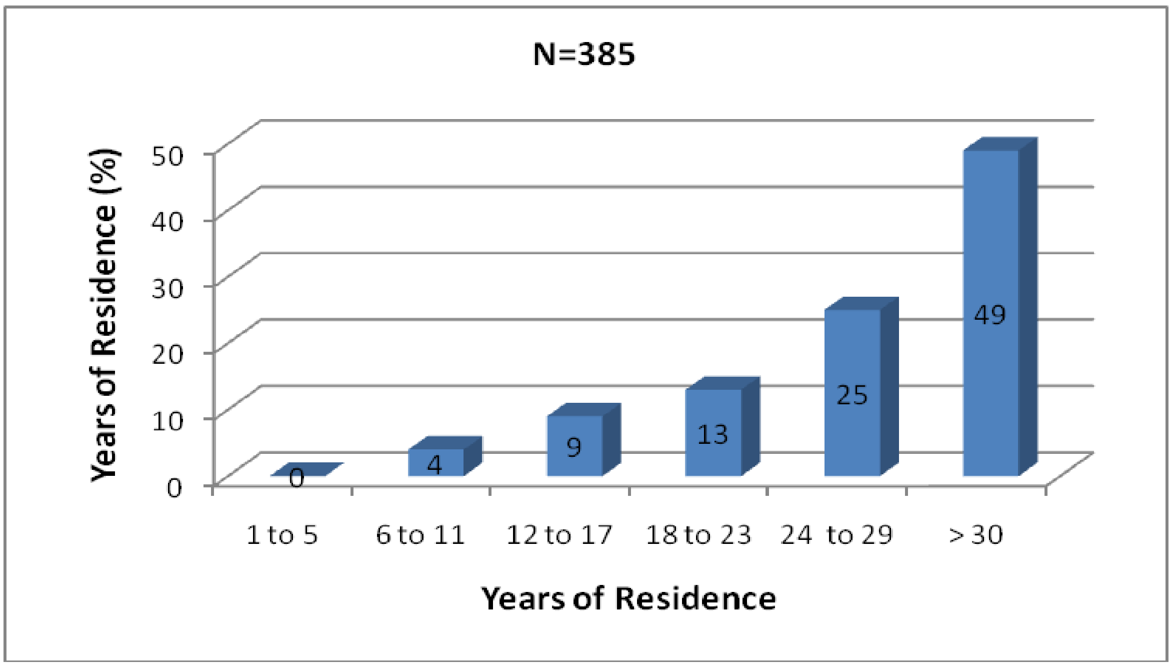

Figure 4.6: Years of residence for household respondents in Siaya County

Source: Field data (2023)

Siaya County being 91.4% rural (GoK, 2020), majority of the household heads 49% composed of the natives confirmed the fact that majority had lived within the study area for more than thirty (30) years. However, there was a population within the study area that lived there for less than 30 years. The study established that they were mostly the formally employed populations that get transferred to and from the study area. Others were the female who got married and had not taken long in the area.

To test the association between period of residence and practice of the disaster risk management approaches for food crop production by the household heads, a correlation analysis was done and the results are as shown in Table 4.6. Correlation coefficient of 0.911 showed a very strong positive relationship between years of residence of a household head and prospective approach, -0.104 showed a very weak negative relationship between years of household head and corrective approach, -0.007 showed a very weak negative relationship between household head years of residence and compensatory approach, and 0.663 showing a strong positive relationship between household head's years of residence and community based disaster risk management approach. Cumulatively, a correlation coefficient of 0.880 showing a very strong positive relationship which was significant at 0.048, $p < 0.05$ was shown from the analysis.

Table 4.6: Relationship between Years of residence and the disaster risk management approaches applied in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Residence	Pearson Correlation	.911	-.104*	-.007	.663	.880
	Sig. (2-tailed)	.033	.842	.893	.217	.048
	N	385	385	385	385	385

Source: Field data (2023)

Results therefore show that there is a strong positive association where the increased number of years one resided the increased and intense application of the disaster risk management approaches by the households towards mitigation of the negative impacts of climate change to improve food crop production in the study area. From the results, majority of the respondents are natives who are mainly engaged in farming that frequently get impacted on by floods and droughts hence adversely been affected by low food crop production in Siaya. The study established that among the farming households, those who had stayed for more than 12 years practiced long term disaster risk management approaches such as in prospective together with other approaches while those who had lived for less than 12 years mainly practiced corrective, compensatory and community-based disaster risk management approaches.

4.2.7: Monthly income from the sale of agricultural produces and the disaster risk management for food crop production in Siaya County

To establish about any monthly income from the sale of agricultural surplus by the households in Siaya County, the results in Figure 4.7 reveal that majority of the respondents 30% (116) had a monthly income between Ksh. 9000 – 12000, followed by 18% (69) had a monthly income between Ksh. 12,000 – 15,000, 15% (58) between Ksh. 15000 – 18000, 11% (42) below or of Ksh. 3000, 9% (34) earned between Ksh. 24000 – 27 000, 7% (27) earned between Ksh. 3000 – 6000, 4% (15) earned between Ksh. 27000 – 30000, 3% (12) earned between Ksh. 18000 – 21000, 2% (8) earned between > 30000, while 1% (4) earned between Ksh. 6000 – 9000 in the study area.

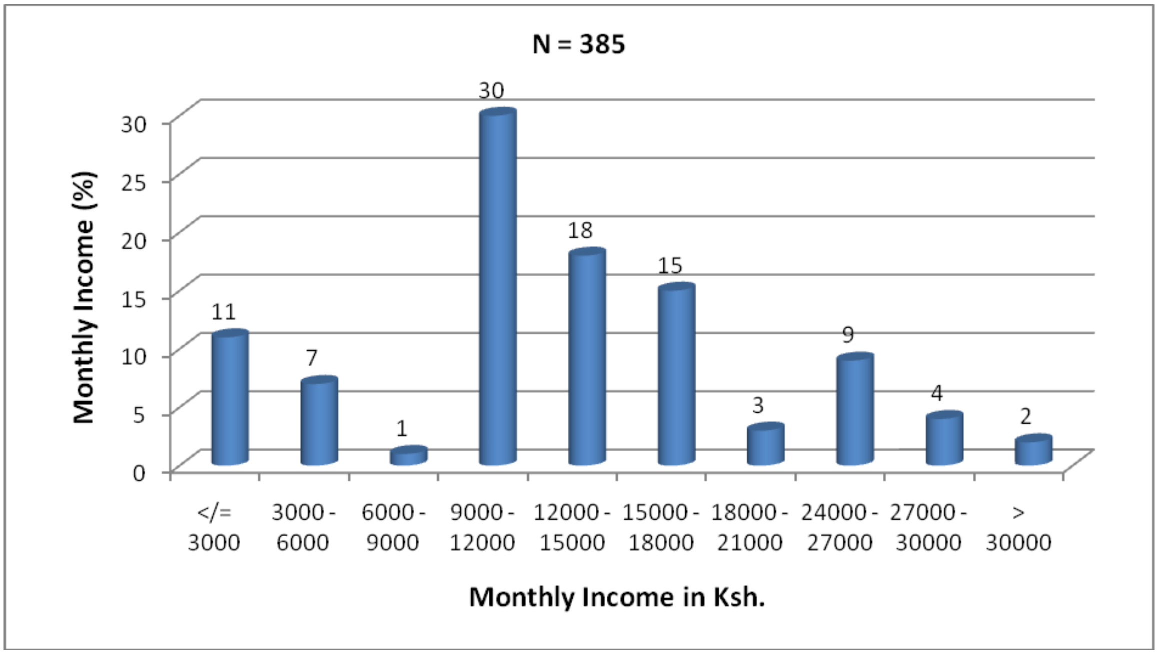

Figure 4.7: Monthly income from the sale of the agricultural produces

Source: Field data (2023)

The analysis indicates that the majority of the respondents earned between Ksh. 9000 – 12000 ($ 69 – 92) per month. It was established that this was mainly from the sales of their agricultural produce such as the kales, eggs, fruits, chicken, goats and sheep. The rest of the population who earned above this had other businesses such as shops while the rest were either casually employed or formally employed.

To establish the possible influence of the monthly income of the household heads on disaster risk management approach practiced, a correlation analysis was carried out as shown in Tables 4.7. The results show a correlation coefficient of 0.809 showing a very strong positive relationship between a respondents monthly income and prospective approach, 0.649 showing a strong positive relationship between respondents monthly income and corrective approach, 0.076 showing a very weak positive relationship between respondent's monthly income and compensatory approach, and -0.079 showing a very weak negative relationship between respondent's monthly income and the practice of community based disaster risk management approach. Cumulatively the correlation analysis summed up the results with a correlation coefficient of 0.523 showing a moderate positive relationship that was statistically significant at 0.035, $p < 0.05$.

Table 4. 7: Relationship between household monthly income and food security in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Monthly Income	Pearson Correlation	.809	.649	.076	-.079	.523
	Sig. (2-tailed)	.017	.033	.539	.123	.035
	N	385	385	385	385	385

Source: Field data (2023)

The results therefore show that there was an association where difference in monthly income positively influenced practices in different disaster risk management approaches in mitigating the negative impacts of climate change mainly to food crop production in the study area. This means that those who had higher monthly income had the potential to actively practice the disaster risk management approaches in mitigating the negative impacts of climate change as opposed to those with low monthly income. This finding resonates with Okunola and Bako (2021) that categorized the climate change mitigation into low cost, medium cost and high cost as influenced by the affordability from varied household incomes. It was established that the majority of household earnings were insufficient hence majority were not in a position to invest the high-cost disaster risk management approaches such as in food crop insurance, pest and disease management and in soil and water management in Siaya County.

4.2.8 Family size of the household respondents and disaster risk management approaches for food crop production in Siaya County

The study sought to establish the family sizes of individual households in the study area where the results are as presented in Figure 4.8. The results indicate that 3% (12) had a family size of 2, 27% (104) had a family size between 2 – 4 members, 43% (166) between 5 – 7 members, 20% (77) between 8 – 10 members, 6% (23) between 11 – 13 while 1% (4) had family size of more than 14 members in the study area. From the results, majority 70% of the households have over 5 members while just 30% have 4 and below members in Siaya County.

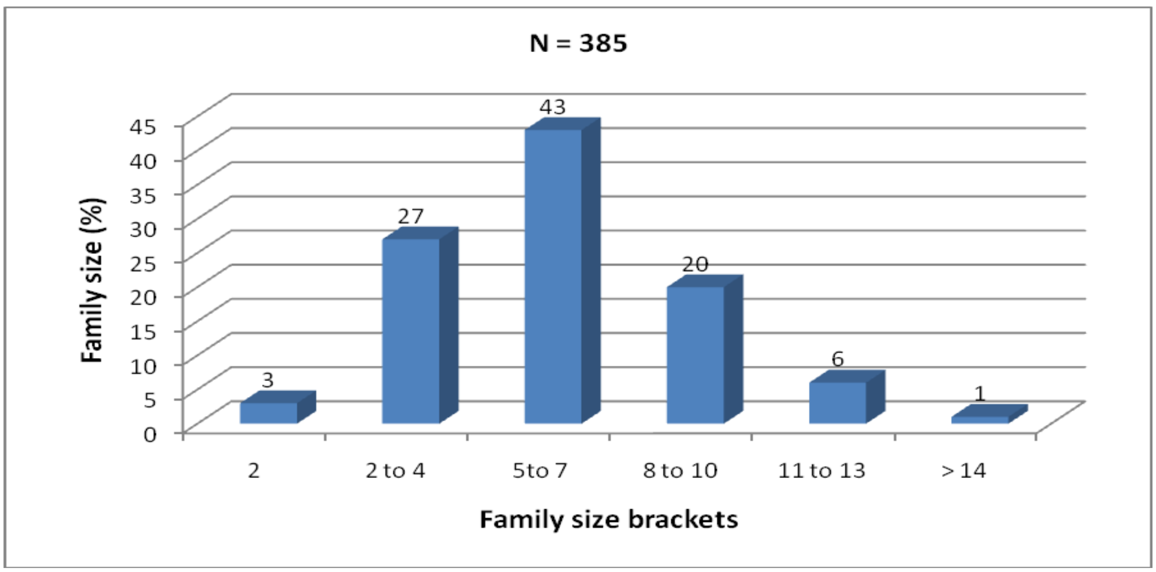

Figure 4.8: Family sizes of the household respondents in Siaya County

Source: Field data (2023)

To establish the relationship between the family size of the households and the disaster risk management applied in mitigating the negative impacts of climate change, a correlation analysis was done and the results are as shown in Table 4.8. Correlation coefficient of -0.830 showed strong negative relationship between family size and prospective approach practice, 0.529 showed a moderate positive relationship between family size of the households and the corrective approach practice, -014 showed a very weak negative relationship between family size of the households and compensatory approach, and -0.016 indicating a very weak negative relationship between family size of the respondents and community based disaster risk management approach. Lastly, correlation analysis between family size and cumulative disaster risk management approaches showed a correlation coefficient of 0.456 that was not statistically significant at 0.423, $p > 0.05$.

Table 4. 8: Relationship between family size and disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Family size	Pearson Correlation	-.830	.529	-.014	-.016	.654
	Sig. (2-tailed)	.222	.313	.791	.748	.423
	N	384	384	384	384	385

Source: Field data (2023)

Analysis therefore show that the varying family sizes had a positive association and influenced though of low significance to the kind of the disaster risk approaches that were applied to mitigate climate change and improve food crop production in Siaya County. It is expected increased man power in larger households translates to increased participation in various disaster management approaches hence increased food crop production. This study therefore resonates with Mose and Mukami (2020) on social predictors of household food production founded on the various agricultural risk reduction activities in Machakos, a county categorized under ASAL like Siaya County indicating a relationship between the two attributes though of no statistical significance.

4.2.9 Land tenure systems of the households and disaster risk management approaches for food crop production in Siaya County

Results in Figure 4.9 reveal that 4.2% (15) of the household respondents were involved in public land tenure, 64.5% (250) practiced freehold, 24.5% (92) of the respondents in leasehold, while 6.8% (27) practiced customary land tenure system in the study area. From the results, the majority of the household respondents practiced freehold land tenure in Siaya County.

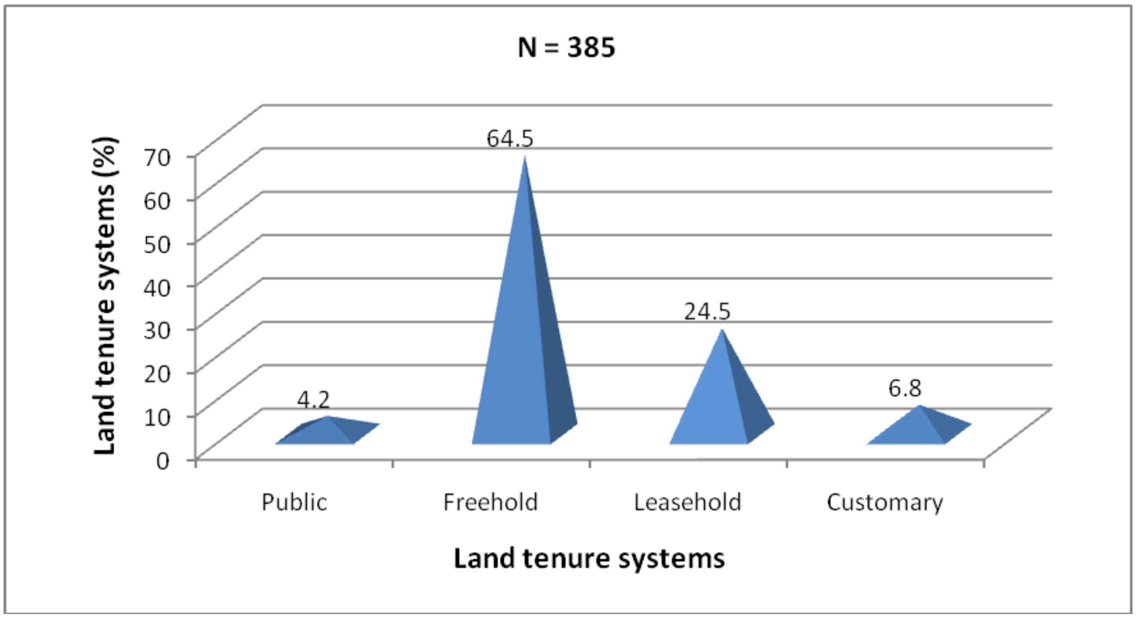

Figure 4.9: Land tenure systems of the household respondents in Siaya County

Source: Field data (2023)

To establish any association between land tenure and disaster risk management approaches applied in mitigating the negative impacts of climate change in Siaya County, a correlation analysis was done and the results are as presented in Table 4.9. Results show that there was a strong positive relationship between the kind of land tenure practiced by the respondents and prospective approach at 0.931 correlation coeficience, -0.070 very weak relationship relationship between kind of land tenure and corrective approach, -0.072 very weak negative relationship between kind of land tenure and compensatory approach, and -0.073 very weak negative relationship between kind of land tenure by the respondents and community based disaster risk management approach. Cummulatively, a correlation coeficient of 0.878 with a significance level of 0.050, p=0.05 was generated from the analysis.

Table 4.9: Relationship between Land tenure systems and disaster risk management approaches for food crop production in Siaya County

		Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA	
Land tenure	Pearson Correlation	.931	-.070	-.072	-.073	.878
	Sig. (2-tailed)	.001	.573	.161	.650	.050
	N	385	385	385	385	385

Source: Field data (2023)

Results therefore show that there is an association where the varioation in land tenure systems influenced the variety in disaster risk management approaches used for to mitigate the negative impacts of climate change for food crop production. The results in Figure 4.9 show that majority (64.5%) of the respondents practice freehold land tenure systems. It was found out that the majority are natives hence land inheritance as a contributing factor to the kind of practice. Secondly, the study established that few of the households or individuals that are involved in leasehold had the financial capability and invested heavily in various disaster risk management approaches while the majority practicing freehold are the natives who most of them have limited or no resources to invest in intensive agriculture hence experience was not highly involved in the various disaster risk management approaches hence low food crop production in Siaya County.

The study established that the two groups as those who practiced freehold and leasehold held larger pieces of land that would be used for food crop production. Mamkwe (2016) on household socio-economic factors and climate change mitigation approaches, farm size in relation to land tenure systems has a significant influence on adoption of the mitigation strategies for climate change for production of food crops. According to Maxwell and Wiebe (1998) it is believed that increased security of land tenure in productive resources dictates the kind of investments individual get involved into and mainly those that are meant to reduce the agricultural risk and those meant to improve agricultural system resilience for increased food crop production in the wake of environmental factors such as climate change.

CHAPTER FIVE

DISASTER RISK MANAGEMENT APPROACHES RELATED TO CLIMATE CHANGE IN SIAYA COUNTY, KENYA

5.1 Introduction

This chapter presents and discusses results from analyzed data derived from specific objective (ii) of the study; to determine the disaster risk management approaches applied in Siaya County. This chapter presents results and discusses findings on various agricultural activities under the various disaster risk management approaches as prospective, corrective, compensatory and community-based disaster risk management approaches as applied to mitigate the negative impacts of climate change on food crop production in Siaya County.

5.2: Disaster risk management approaches that are related to Climate Change in the study area

In line with objective (ii), the study sought to establish the various disaster risk management approaches that are mostly related to climate change in Siaya County. The results in this section set ground for investigation of agricultural resilience that may contribute to increased food crop production.

5.2.1: Prospective disaster risk management approach related to climate change

This section analyses and discusses activities under the prospective disaster risk management approach such as a) Greenhouse gas reduction activities, b) Land use planning, c) Agroforestry, and d) early warning climate information activities which respondents use to attain increased food crop production. Figure 5.1 show that 45% (173) of the household respondents identified with Green Gas House emission reduction, 18%

(69) land use planning, 11% (42) agroforestry and 26% (100) early warning information as the risk approaches that are mostly practiced in the efforts to avoid occurrence and the possible effects of climate change in the study area. The results indicate that majority of the respondents' recognized Greenhouse Gas (GHG) reduction activities as the most related to climate change in Siaya County.

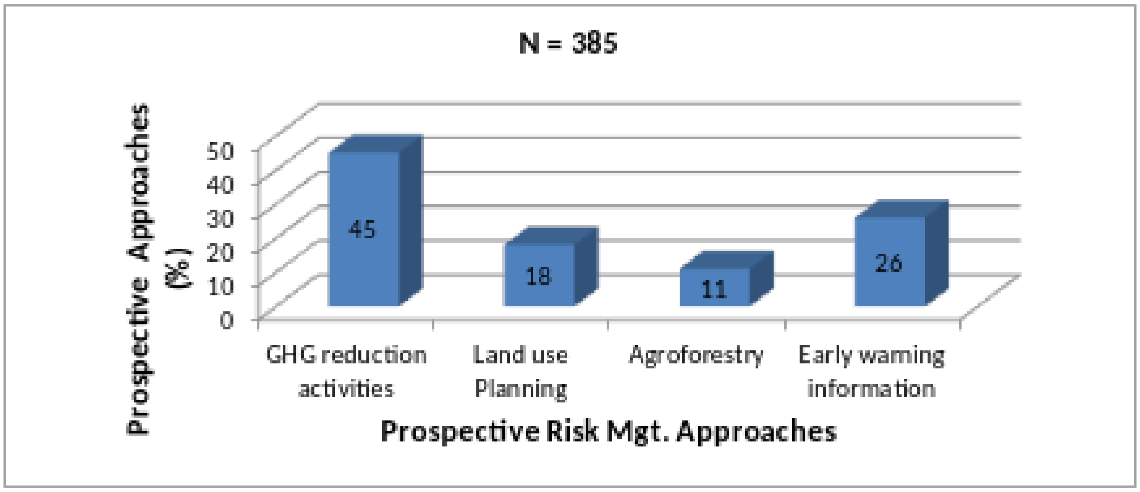

Figure 5.1: Prospective disaster risk management approaches in Siaya County

Source: Field data (2023)

According to GoK (2021a), Siaya County faces a range of challenges related to climate change such as greenhouse gas effects, land use planning and deforestation. Soil is one of the most important natural resources with regard to agriculture and majorly its pivotal role in food crop production. According to GoK (2021a), Counties grouped under ASAL like Siaya get barely 25% of the potential yield due to the challenges of soil erosion, greenhouse gases, poor land uses, poor rainfall amount received and poor timing for agricultural activities. This trend therefore triggered the need to investigate the prospective disaster risk management approach activities associated with mitigation of climate change for food crop production in Siaya County.

5.2.1.2 Greenhouse Gas reduction activities in Siaya County

Due to the increasing demand for food from the soil, there has occurred increased intensification and utilization of the soil through nitrogen fertilizer applications, slash and burn activities, charcoal burning and overgrazing thereby increasing greenhouse gases such as carbon dioxide, nitrous oxide and methane in the atmosphere. Figure 5.1 show that majority of the household heads 45% related mostly with the greenhouse gases reduction activities such as use of Biochar and composed manure (Plate 5.1) as prevention measure of increased risks from climate change such as of floods and droughts in Siaya County. The study sought to conduct further analysis using inferential statistics to establish the level of significance of greenhouse gas reduction activities to climate change negative impact prevention. The results from the inferential analysis exhibited a Chi – square test ($\chi^2_{5,0.05}$ = 12.02) with p-value of 0.04 at ($P<0.05$). The analysis shows that there is a statistical significance of greenhouse gas reduction activities to climate change related disaster risks. This therefore means that there is a significant number of households in the study area that practice greenhouse gas reduction activities in preventing the increased negative impacts of floods and droughts on their food crop farms for increased food production.

According to IPCC (2022), agricultural soil contributes to approximately 5% increase in greenhouse gases in the atmosphere by emitting nitrous oxide and methane due to use of nitrogen fertilizers, intensive usage of other inputs such as pesticides and herbicides for farming. The study however established various greenhouse gases reduction practices that contributed to the prevention of the climate related disaster risks mainly through making compost. This involved burying organic matters mainly of specific plants and livestock waste from their farms that are accumulated in large quantities and over a period of time and later used as fertilizers to grow crops. Additionally, there was use of Biochar which were fixed around the roots of the crops to reduce nutrient leaching from the soil and also used to reduce greenhouse gases emission into the atmosphere. This finding resonates with Gonzalez-Sanchez *et al*. (2022) that strategies such as climate smart agriculture and specifically effective management and utilization of manure can significantly reduce the greenhouse gas hence mitigating the climate change risks.

Plate 5.1: Compost manure preparation by small scale farmers in North Alego ward

Source: Field data (2023)

5.2.1.2. Land use planning in Siaya County

The study established that the respondents practiced land use planning activities at the household farm levels such as restricting food crop farming along the existing water sources and wetter areas like the highlands to prevent agricultural drought and others along the slopes to prevent being affected by floods in different seasons and buffer zoning using napier grass and gravellier tree planning from pest. Figure 5.1 show that 18% of the household heads respondents related land use planning as a prevention measure to the increased risks from the changing climate in Siaya County.

The study conducted inferential analysis to test the level of significance of the land use planning in preventing increased risks of drought and floods from the changing climate in the study area. Results from the inferential analysis a Chi – square test ($\chi^2_{5,0.05} = 19.02$) with p-value of 0.05 at (P=0.05) indicated a statistical significance of land use and planning in preventing future disaster risks of floods from the changing climate. This means that a significant number of the households in the study area have adopted land use and planning in avoiding any future risks of mainly flooding on their food crop farms for increased food crop production.

Figure 5.2 shows agricultural land use land cover map where food crop such as maize, beans, sorghum, sweet potatoes, cassava farming that are mainly rain-fed covered the largest area at 71.91% of the total land cover in the study area. This was followed by scattered rainfed tree crops at 21.86%, scattered rainfed herbaceous crops at 3.3%, irrigated herbaceous crops at 1.56% and isolated natural vegetation at 1.37% of the total land cover in Siaya County. The high percentage, 71.9% of the rain dependent food crops are however, grown on specific areas guided by ecological suitability and capability to avoid getting adverse impacts of drought and floods by integrating it with other vegetation for increased ecological services such as increased rains and reduced water runoffs to the benefit of the food crops.

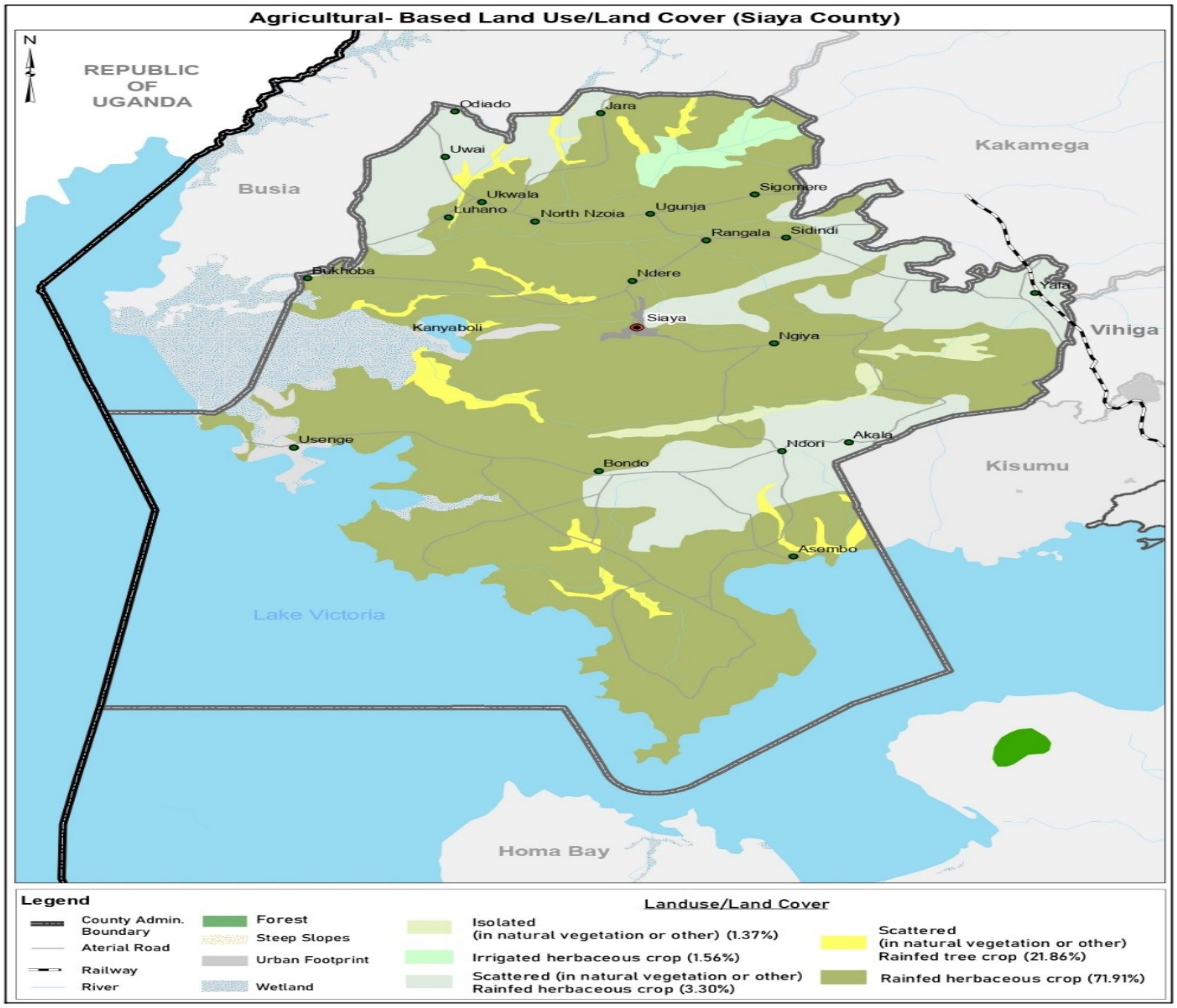

Figure 5.2: Agricultural land use cover map of Siaya County by September 2023

Source: Researcher (2023)

The areas that they put restrictions based on the ecological suitability to food crops production are mainly around the low lands to prevent agricultural droughts from affecting the food crops while this is integrated with tree crops such as a preventive mechanism against floods negative impacts on the crops on the highly hazardous areas to floods such as along river Nzoia and at the lake shows of Victoria and Lake Kanyaboli.

These findings are supported by the Siaya County Integrated Development Plan GoK (2022) that land use planning is a factor of consideration as climate change mitigation strategy to prevent the negative impacts floods mainly on agricultural activities around the existing water bodies such as River Yala and Nzoia and the sloppy areas in Siaya County.

Climate change has a range of impacts in all dimensions of development such as in agricultural food crop production for food security. Integrating Land use planning into food crop production with the full recognition of climate change occurrence has the potential to prevent the climate change negative impacts from floods, drought, heat stress and water scarcity (Morosini and Zucaro, 2019). Pearson *et al*., (2017) also asserts that land use planning has the potential to reduce the vulnerability to certain natural resources like land and to prevent impacts of natural disasters that are climate related like floods and drought.

Secondly, the respondents identified use of trees such as gravellier and other crops such as Napier grass (Plate 5.2). These are used as buffers around crop lands and in between crops and crop intervals. These practices are used to protect pest that are largely as a result of climatic changes such as desert locust that migrate with the changes in climate in a given environment. The study observed that buffer zoning was just a temporary protection of the crops. The participants explained that this depends on the magnitude and intensity of the pest’s invasion where incase of high or increased and sudden number and invasion, then the crops may not be spared.

Plate 5.2: Use of Napier grass as a buffer to protect crops from pests in Siaya County

Source: Field data (2023)

According to the Key informants, who was the programs officer with Kenya Climate Smart Agriculture Program in Siaya County:

> "Land use management has the potential to increase resilience to major climate changes and ensure that communities are capacity built with better mechanisms to mitigate the changes".

Additionally, a key informant from the Department of Agriculture in Siaya County:

> "Most areas mainly of hazardous nature are not yet zoned and that for an effective and sustainable land use planning in the view of climate change and impacts, there in need for a more strategic and integrated and long-term approach as opposed to the traditional measures such as mere avoiding the flood prone areas for agriculture".

5.2.1.3 Agro-forestry practices in Siaya County

The study established that the respondents were engaged in a range of activities that contributed to the vegetative cover such as in nurturing of seedlings for sale and distribution to schools and farmers mainly by youths in groups. Figure 5.1 indicates that 11% of the household heads respondents related agro-forestry practices to prevention of the increased risks of floods and droughts from the changing climate in Siaya County. Additionally, the study further conducted an inferential statics analysis to test the level of significance of the agro-forestry as a prevention measure to the risks from the changing climate. Results from the inferential analysis showed a Chi – square test ($\chi^2_{5,0.05}$ = 23.01) with p-value of 0.059 at (P>0.05) indicating no statistical significance of agro-forestry towards prevention of the increased risk from the changing climate where according to the analysis, agroforestry does not contribute to the prevention of the disaster risks mainly of floods and drought in the study area.

Siaya County, over the years has experienced low forest cover up to 2% over an area of approximately 2,496-kilometer square (GoK, 2022). This situation has only exacerbated threat to food crop production due to low or no rains for agricultural activities because agriculture in Siaya County is largely rain fed. According MoALF (2016), poor environmental practices such as deforestation have persisted leading to reduction of vegetation cover hence leading to significant decline in food crop production of mainly maize and beans due to reduced rainfall amount received within the crop farming seasons in Siaya County.

Forests are known to be greenhouse gas sinks therefore, establishing tree plants in the same agricultural lands for example in the crop lands has the ecological function of greenhouse gases such as carbon dioxide and methane sequestration from the atmosphere. According to IPCC (2021), the increased level of carbon dioxide in the atmosphere is directly attributed to lack of enough vegetation cover or deforestation which in turn has the potential to cause global warming hence climate change. It means that climate change consequently has the potential to generate climate change risks such as excessive rains leading to floods and persistent lack of or experience of abnormally low amount of rains hence drought within a given place and time.

The study therefore established that due to the concern about climate change risks from low forest cover, the respondents and the larger population of Siaya County have engaged themselves in agro-forestry practices (Plate 5.3) to prevent extreme climate change occurrences. It was established that the afforestation and reforestation initiatives are undertaken by different stakeholders like the County Government, NGOs such as World Vision, Welthungerhilfe, Plan Kenya and Red cross society; and also, Community Based Organizations such as "Tembea" Youth for Sustainable Development working in Siaya to improve the forest cover amidst crop farming. One of the initiatives established by the study is by the "Sauti Kuu" an initiative by Auma Obama foundation within Siaya County and specifically in Alego Usonga. The agro-forestry initiative has the objective to increase forest cover that will in turn influence the rainfall pattern. According to Olivier and Peters (2020), agro-forestry is a strategic method used to mitigate the negative impacts of climate change by increasing greenhouse gases sequestration from the atmosphere to reduce global warming hence improving on the amount of rainfall amount received suitable for food crop production.

Plate 5.3: Agro-forestry practiced by a small scale farmer in North Alego, Siaya County

Source: Field data (2023)

Secondly, through Focus group discussions, the study established that Community Based Organization work with communities to nurture seedlings and distribute in the community for planning. The CBO, "Tembea" Youth for sustainable development activities are founded on climate change mitigation and enhancement of sustainable development within Siaya County.

A Key Informant, program coordinator with the Tembea Youth Initiative for Sustainable Development said:

> "We have managed to mobilize resources and community members to plant over 30,000 trees and facilitated establishment of over 25 tree nurseries across the county of Siaya from the year 2021. This we expect to go a long way in increasing the vegetative cover amidst crop farming within the County of Siaya with the focus on mitigating climate change".

Additionally, there are other initiatives such as by the Kenya Forest Services in partnership with the County Government of Siaya to increase the Forest Cover. There are claims on the over reliance of the existing learning institutions on firewood as their main source of fuel (Plate 5.4) and therefore need for collaboration to increase the vegetation cover. According to a Key Informant, Afforestation program coordinator with the Kenya Forest Services in Siaya;

> "Schools totally rely on trees for fuel hence they contribute highly in deforestation in Siaya County. This is a challenge and also an opportunity by the high number of students in school who can be used to plant and nurture the tree to maturity to restore the tree cover within this county".

Plate 5.4: Piles of firewood used for cooking in one of the secondary schools in North Ugenya Ward, Ugenya sub location

Source: Field data (2023)

The study hence established through the interview that there exists afforestation program between the Kenya Forest Service and the schools practiced on the school farms (Plate 5.5) to plant more than one hundred thousand (100,000) tree every year in Siaya County since the year 2019 and this has seen a significant increase in tree cover. According to GFW (2020) Siaya County has gained 793 ha of tree cover translating to approximately 0.80% contributions to the national vegetation cover. This may be attributed to the concerted efforts by the various initiatives on agro-forestry in Siaya County. This sentiment resonates with the GoK (2022) that Siaya was barely 10% covered by trees in the year 2000 but there has occurred improvement to an extent of attaining over 38%

currently that is directly attributed to the efforts of small-scale farmers through agro-forestry practices in the study area.

Plate 5.5: Kenya Forest Service and Schools forestation program conducted in one of the schools, Majiwa Secondary in Bondo Sub County.

Source: Field data (2023)

5.2.1.4 Early warning systems in Siaya County

Figure 5.1 shows that 26% (100) of the household heads related early warning systems practices such as behavior of "Osogo" weaver birds and "dede" locusts to prevention of increased risks of floods and droughts from the changing climate in the study area. Further, to test the level of significance of early warning practices to prevention of the increased risks of floods and drought on food crop production. An inferential statistics analysis was done and the results displayed a Chi – square ($\chi^2_{5,0.05}$ = 29.03) with p-value of 0.039 at ($P<0.05$). This showed that there was a statistical significance of early warning systems in prevention of the disaster risks of floods and drought from food crop production in Siaya County.

The study established that both indigenous and scientific systems of early warning information are used in Siaya County to alert the general community on possible weather extremes that may affect their food crops both on and off farm. Some of the indigenous knowledge as established were monitoring birds known as “Osogo” movement towards the north that signified near heavy rainfall and movement towards the south signified rains cessations. Secondly, indigenous predictions involved observing and monitoring insects like locust “dede” appearing during early phenological stages of plant crops signify expected food shortage or food insecurity. Thirdly, Stars appearing in the East signified short rains while in the west, long rains. Cluster surrounded by halo signified good rain season while dull clusters signified no rains or poor rain season expected that may negatively affect food crop production hence food insecurity.

Additionally, the study established from the Kenya Meteorological Department that the communities and especially farmers highly get adequate and timely information from the department about weather and climatic risk possible occurrence in Siaya County. It was further established that the information entailed possible areas that may be affected by the changes for avoidance such as the river banks of Rivers Yala and Nzoia and possible increase in water levels in the Lake Kanyaboli and Lake Victoria catchment areas.

Early warning comprises of detection, analysis, prediction and then dissemination of the information that is expected to build a sound decision making for better response in prevention or avoidance of the climatic risks such as floods and drought from impacting on the agricultural production. Currently, use of indigenous knowledge in predicting weather patterns is accepted under UNESCO Parameters as one of the most accurate methods of predicting climatic events such as rains and drought. This is clearly demonstrated by the "Nganyi rain makers of Bunyore" community in Western Kenya (Ochieng and Kamau, 2013).

5.2.2 Corrective disaster risk management approach in Siaya County

This section analyses and discusses activities under the corrective disaster risk management approach such as a) Soil and water management strategies, b) Drought tolerant crops, c) Pests and disease management, d) Crop diversification, e) Improved post-harvest storage, and f) Flood management. The results as presented in Figure 5.2 indicates that 33% (127) of the household respondents in the study area practice soil and water management strategies, 40% (154) practice drought tolerant crop and livestock keeping, 8% (31) pest and disease management, 14% (54) crop diversification, 3% (12) improved storage facilities, and 2% (8) mainly practicing flood management strategies in reducing the possible occurrence and effects of climate change on food security in the study area

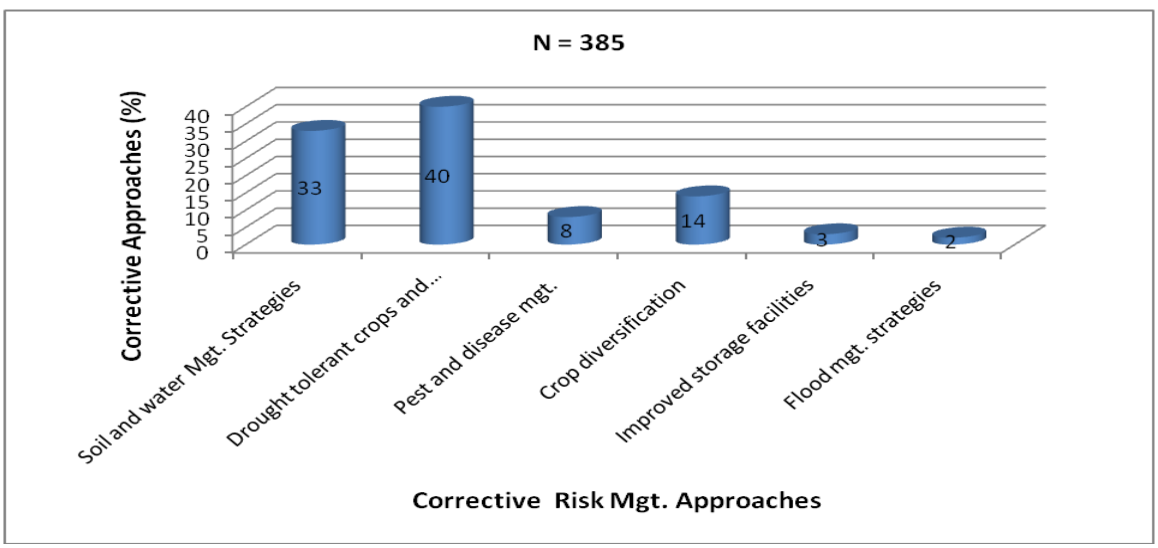

Figure 5.2: Corrective disaster risk management approaches in Siaya County

Source: Field data (2023)

5.2.2.1 Soil management in reduction of climate change impacts in Siaya County

The study established that households practice various activities that are related to nutrients improvement and management, conservation agriculture and regenerative agriculture. Under these categories, were use of mulching and cover crops such as bean, peas and sweet potatoes with a focus on increasing vegetative cover on the soil and hence reducing the amount of moisture that can be lost through evaporation (Plate 5.6). Results from the descriptive analysis in Figure 5.2 shows that 33% (127) household respondents related soil and water management to the reduction of negative impacts from the risks of floods and droughts under the changing climate in the study area. An inferential analysis to test the level of significance of soil and water management practices to the reduction of climatic risks of floods and drought negative impacts was conducted. A Chi – square test ($\chi^2_{7,0.05}$ = 33.06) with p-value of 0.02 at ($P<0.05$) result was generated showing statistically significant soil and water management practices in mitigating floods and droughts negative impacts. Analysis therefore shows that soil and water management have been used for their significant contribution in lessening the negative impacts emanating from climate change in Siaya County.

Plate 5.6: Cover crop (sweet potatoes) farming by small scale farmers in East Ugenya ward for soil and water management
Source: Field data (2023)

Soil and water management entails operations and practices that are geared towards protection of the soil and increase production through improved soil fertility and health Omenda *et al.* (2022). Soil is an important component in agricultural production that has a direct contribution towards food security. It faces a range of challenges such as deforestation and soil erosion that may reduce its performance.

According to GoK (2021b), Siaya County is one of the first Counties in Kenya to domesticate soil management policy. The policy advocates for usage and management of soil in a manner that is equitable, efficient, productive and sustainable. These policies are specifically geared towards reduced soil challenges and minimization strategies to the challenges in relation to climate change and its negative impacts. As a result, it is expected that there would be increased food crop production from increased soil performance to the effect of the policy.

Additionally, the study established that there are organisations such as Kenya Climate Smart Agriculture program in Siaya that have exerted efforts in implementing conservational agriculture such as mulching, minimum tillage and growing of cover crops like potatoes to improve on soil and water management. According to UNDRR (2019), alternatives for sustainable agriculture in enhancing increased food crop production for small scale farmers in the fingerprints of climate change are regenative and organic agriculture which is in line with the agricultural practices among households in Siaya county.

5.2.2.2 Drought tolerant food crops in reduction of climate change impacts Siaya County

In Siaya county, drought tolerant food crops are grown with the main one as sorghum (Plate 5.7), together with cassava, finger millet and potatoes. Results in Figure 5.2 shows that 40% (154) of the household respondents related drought tolerant food crops practices in reducing the negative impacts of droughts. Further, inferential statistics analysis was conducted to test the level of significance of the drought tolerant food crop practices in reduction of the negative impacts of and droughts on the food crop. Analysis from a Chi – square test ($\chi^{2}_{7,0.05}$ = 20.30) with p-value of 0.001 at ($P<0.05$) show a high statistical significance of the practice of drought tolerant food crop by the households in the changing climate to reduce the negative impacts of droughts. These drought tolerant food crops have high potential to maintain food production given that they require low amount of water to grow, develop and produce and are resilient to the extreme high temperatures.

Plate 5.7: Sorghum farm during drought season in North Sakwa, Siaya County

Source: Field data (2023)

The results from this study agree with the findings of Acevedo *et al*., (2020) on a scoping review of adoption of climate resilient crops by small scale producers in low and middle income producer counties. Findings from the study showed that majority 53% increased their food crop production by practicing drought tolerant food crops under the finger prints of droughts and heat waves in the low and middle income countries. Additionally, Ashraf (2010), asserted that the concept behind drought tolerance is enhancement of resilience of food crops in different areas under the changing climate. It means that, there is need for on farm practices and selection of crop types that are able to maintain their biomass during drought situations.

The study established from focus group discussions that majority in the community practiced farming that involved crops that are drought tolerant. These were mainly characterised by the indegenious varieties of food crops that are more resilient to drought and its impacts.

Key informants as the Director of the County Department of Agriculture stated that:

> "Sorghum stands out as the crop that is reliably grown by majority and generally in Siaya County that is drought tolerant and highly identical with certain regions of Siaya County like Alego Usonga, Bondo and Ugenya and Uyoma". Additionally, we also have drought tolerant livestock that are mainly of indigenous goats in areas like Bondo and Alego Usonga that are of range lands that suits these livestock than other areas within Siaya Country".

According to MoALF (2016), there are a range of on – farm strategies to cope with climate risks and shocks such as drought. These comprises of planting of drought tolerant crops and animal feed conservation to take care of the drought tolerant livestocks during the extreme climatic conditions. Replacing maize with drought tolerant crops such as sorghum, millet, pigeonpea, cowpea and green gram have helped farmers overcome the failure and unpredictable rains impact in most Western Kenya Counties Like Siaya and Busia (FAO, 2014).

5.2.2.3 Pest and Disease Management in Siaya County

The study established that there are a variety of pests such as fall army worm, stalkborer, cartapillars, locusts; and diseases such as bacterial leaf blight, leaf streak, stalk rot that have signifcantly affected production of dominant food crops of maize, sourghum, millet and beans in the study area. Results in Figure 5.2 shows that 8% (31) of the household respondents related pests and diseases management practices to reduction of the risks of floods and droughts from the changing climate in the study area. To test the level of significance of pest and diseases management in reducing climatic risks impacts, an inferential statistics was conducted. A Chi – a square result of ($\chi^2_{7,0.05}$ = 30.10) with p-value of 0.049 at (P<0.05) was generated from an inferential statistical analysis. Analysis therefore shows that though of low-level statistical significance, households practice pest and disease management in reducing the negative impacts of disaster risks of drought and floods from the changing climate in Siaya County.

There is a close relationship between climate change and pests and diseases, they determine the spread and distribution and population size of the pests and diseases. This is based on the favourability of environmental conditions in a given location for specific pest and disease causing agents. Temperature and rainfall are the main drivers of the locations where pests and diseases occur (Dent and Binks, 2020). Where, an increase in temperature levels have in many ways favoured the reproduction and distribution of different species of pests and disease causing agents.

According to FAO (2019) pests and diseases are a threat and results to over 40% of the food crop lost in many parts of Kenya relating to Siaya County. Findings revealed that Siaya County experiences a wide variety of pests and diseases that in turn affect food crop production in the farms contributing to food insecurity. It was established that the pests have caused more harm in areas mainly in North Alego, Yimbo East and Ugenya.

Pests and diseases were mainly managed through mechanical, traditional methods including use of resistant crop varieties, use of mulching, traping, prunning and burning of the affected crop plants and handpicking of the pests, chemical and biological methods. However, the study established that there are those methods that seemed to be costly to the farmers there by making the low number of households being engaged in using them to manage the pests and diseases in the Siaya County. Findings of this study therefore are in tandem with Parsa *et al*., (2014) on the obstacles to integrated pest and disease management adoption in developing countries that found out that poverty a determinant in affording the most sustainable and pest and diseases management methods among the small scale food crop farmers in the developing countries.

5.2.2.4 Crop Diversification in Siaya County

In Siaya County, small scale farmers practice crop diversification and the study established that among crops that are diversified are maize, sorghum, millet, beans, finger millet, beans and cow peas, cassava and sweet potatoes. In Figure 5.2, results show that 14% (53) of the household heads related crop diversification practices as one of the effors in reducing the negative impacts floods and droughts from the changing climate in the study area. In efforts to complement descriptive analysis, the study conducted an inferential statistics analysis to test the level of significance of usage of crop diversification. A Chi – a square test ($\chi^{2}_{7,0.05}$ = 22.09) with p-value of 0.03 at ($P<0.05$) results was generated showing that there is statistical significance in practice of crop diversification by the households in the study area in reducing the negative impacts of floods and droughts from the changing climate in Siaya County.

According to Linn (2011), crop diversification is the growing of a variety of crops in a farm for a maximized return and in relation to the existing risks such as climate change negative impacts that may affect the crops in the farms. Based on the different characteristics exhibited by different crops in terms of resistance, tolerance and largely resilience to climatic risks like drought and floods, farmers have an opportunity of planting the variety to take care of the challenges and harvest from those that may not be affected by climate change impacts. The results from this study therefore agree with Birthal and Hazrana (2019) that, diversification and resilience of agriculture to climatic shocks that crop diversification is one of the management options that has been adopted in rainfed systems that have over the years in different parts of the world helped in mitigating against the negative impacts of climate change.

The study established that the households use diversification to mainly spread the risk of total loss of one type of crop incase climatic and related risks impact the gowing season. However, according to program cordinator as a Key informant, from the Kenya Climate Smart Agriculture Project in Siaya, the diversification not only spread risks on cropping and production but it also spreads economic risk over different crops and in relation to the extreme climatic condition impacts.

In relation to sudden and adverse climatic condition like drought, heat stress, hailstone, invasion of pest and disease and floods, crop diversification has the ability to withstand the negative impacts on the crops and equally tolerate the increasing and decreasing prices of the various farm products hence economic stability. The study therefore confirmed that among the farmers, cereal crops like sorghum, maize and millet and root tube crops like cassava and sweet potatoes were a characteristics of many farms in most households in Siaya County to reduce the possible impact of climate change on food security.

5.2.2.5: Post-harvest storage facilities in Siaya County

The study established that majority of the households practice small scale farming hence the existing post harvest storages faccilities are small scale storage options such as sacks, cans, drums and cribs (Plate 5.8) while just a few have managed to build modern storage buildings. The study results in Figure 5.2 show that 3% (16) of the household respondents related storage facilities usage to the reduction of the negative impacts of climate change related risks of floods and droughts in the study area. In order to test the level of significance of the usage of storage facilities by the households in reducing the negative impacts from floods and droughts, an inferential statistics was done. Analysis showed lack of statistical significance giving a Chi – square ($\chi^2_{7,0.05}$ = 13.20) with p-value of 0.051 at ($P>0.05$) in the usage of the storage facilities by the households in the study area to reduce the negative impacts of floods and droughts under the changing climate in Siaya County.

After crop havesting at the end of any given season, it is expected that the food crops from the farms are stored in places where they can not be damaged by the varying climatic conditions like erratic rains and floods. Storage of food crops is done awaiting transfer to the market for the supplus and also stored to cusion the farmers during seasons of poor harvests. However, the study learnt that majority of the households store food mainly for consumption purposes and very little for sales. The results from this study were consistent with Niles *et al*. (2016) findings on farmers intended and actual pactices of climate change mitigation strategies and specifically storage facility which was dependent on the capacity to produce agiven amount of food. It means that those who have the ability to produce more had the highest chances to adopt the usage of storage facilities contrary to those who do not have the capacity due to the effects of climate change.

Plate 5.8: Traditional storage facility (crib) used as a post-harvest storage facility in Yimbo East, Siaya County

Source: Field data (2023)

According to FAO (2020) Siaya County experiences loses of over 30% of the food produced due to poor storage facilities that are vulnerable to the climate change risks like floods hence contributing to food insecurity. The study futher established that there existed other storage facilities within the counties such as modern stores, traders stores, and the National Cereals and Produce Board stores that were constructed by different stakeholders in agriculture and post harvest storage in Siaya County.

From a key informant (County Director) Department of Agriculture in Siaya County:

> “Apart from the small scale storage methods, there are individuals who have and use modern storage facilities mainly in Bondo and Yala Gem that have helped in better storage. These storage facilities were constructed by the national government while other were by the help of NGOs such as the one by World Vision in Siaya Township, Dominion factory store in Alego Usonga, and Nyawara animal feed store by Western Kenya Commnuity Development in Yala Gem”.

5.2.2.6: Flood management strategies in Siaya County

In Siaya County, some of the strategies used to manage floods are planting trees on the slopes of the flood prone areas to regulate the speed of surface run offs and terracing on the slopes of the farms, relocation from the high risk areas and awareness creation by the community members. Results in Figure 5.2 show that 2% (8) of the households respondents related flood management practices to reduction of the negative impacts of floods from the changing climate in the study area. Further, to test the significance level the practice of flood management strategies by the households in reducing the negative impacts of floods, an inferential stastics analysis was done that showed a Chi – a square result of ($\chi^2_{7,0.05}$ = 50.30) with p-value of 0.057 at (P>0.05). This indicates that there was no statistical significance in the practices of floods management strategies by the households in reducing the negative impacts of floods in Siaya County.

According to GoK (2022), flood occurrence is one of the challenges facing Siaya County either affecting those in the low lands or those households living a long River Yala, River Nzoia and also along the Lake Victoria when the Lake water rises mainly as a result of increased rains due to climate change. The study established that some of the areas that have frequently been affected by the floods in Siaya County are West Ugenya due to breakage of River Nzoia banks, Nyadorera in Alego Usonga. According to MoALF (2016) these two areas are agricultural hubs that not only provide food to the locals but also to the neighbouring Counties. It therefore means that whenever there is flooding in these areas then agriculture is highly impacted on negatively hence affecting food crop production within households in the study area.

It was established that there are strategies that are used to mitigate the possible negative impact of floods on crops lands which were structural including construcion of storage facilities, tree planting on the slopes and flood prone areas to regulate the speed of surface run offs, terracing on the slopes (Plate 5.9). Non structural measures included relocating from physically vulnerable locations to floods based on the historical flood occurences, possible time of occurrence and the elements at risk such as crop farms and other agricultural critical infrastructure like storage facilities to higher and safer grounds was considered. Other non structural measures such as creation of awareness about the impending risks of floods and their possible negative impacts on crop lands and storage facilities was also taken into concideration. The study established that households integrated scientific and indegenuos warning signs to alert members of possible floods mainly from both the Kenya meteorological department through chief meetings in the communities.

Plate 5.9: Terracing and tree planting on the slopes of Siraufuongo in Ugenya Sub County

Source: Field photos (2023)

Additionally, key informant from the Department of Environment and Climate change pointed out certain efforts that have been put in place by the county government in pattnership with the National Government and other Non Governmental Organizations. Dyke construction and embankment enhancements (Plate 5.10) in Nyadorera had a significant contribution to the flood risk management in Siaya County. Better management of the floods are therefore expected to reduce the possible impacts of the floods to crops and livestock significantly. Equally, the community had critical facilities like schools constructed on the high and safe grounds that were mainly used during the floods to store food crop produce.

Plate 5.10: Part of the earth dyke for flood management in Nyadorera in Alego Usonga Sub County

Source: Field photos (2023)

5.2.3: Compensatory disaster risk management approach in Siaya County

This section analyses and discusses various practices related to compensatory disaster risk management approach such as a) contigency funds, b) crop and livestock insurance, c) safety nets and d) agricultural subsidies to manage the residual risks of floods and drought in the signatures of climate change from the results as presented in Figure 4.3. The study sought to establish the approaches that are mainly used by the household heads to mitigate the effects of climate change and transfer risk of food crop loss in the study area. The results illustrates that 52% (200) were well conversant and had been involved in subsidised agriculture, 9% (35) had been involved in safty net strategies, 37% (143) incorporated in crop insurance, and 2% (8) had been involved in contigency fund in the study area.

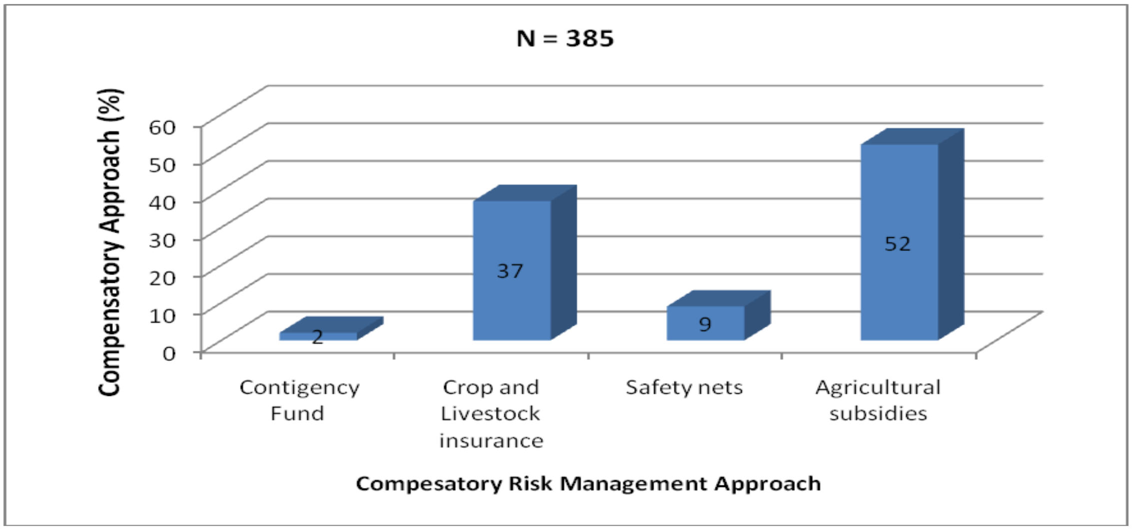

Figure 4.3: Compensatory disaster risk management approach activities in Siaya

Source: Field data (2023)

5.2.3.1 Agricultural subsidies in Siaya County

The study established that some of the subsidy provisions in the study area were mainly of inputs such as subsidised fertilizers, subsidised cost of ploughing using County bought tractors and subsidised certified seeds. Results in Figure 5.3 show that majority 52% (200) of the household respondents related agricultural subsidy services to management of the residual risks from the effects of climate change in the study area. Additionally, inferential statistics analysis was done to test the level of significance of agricultural subsidies by the households in the management of the residual risks from climate change impacts. Results displayed a Chi – square test ($\chi^2_{5,0.05}$ = 12.19) with p-value of 0.001 at (P<0.05). This showed a high statistical significance of the practice of agricultural subsidies by the households in the Siaya County.

The results from this study agree with Oluwatoba *et al*., (2019) on subsidies for agricultural technology adoption in Uganda where the findings revealed that increased accessibility of the different forms of agricultural subsidies increase adoption hence the potential of managing the residual risks mainly that are from the effects of climate change. According to GoK (2021b), County Government of Siaya has made strides in establishing agricultural subsidies by enacting a bill in 2021 on County agriculture input and subsidies. This enactment was meant to instutionalize and operationalize the County agriculture input subsidies and grants programs to enable farmers access quality and affordable inputs that could be realized by supporting strategic interventions enhancing productivity, value addition, quality improvements and marketing. This intervention therefore could have leveraged the level of engagement in the agricultural subsidies as shown by the results in this study (Dulal *et al*.,, 2015).

The study established that most of these subsidies are input based where the County Government of Siaya had a program of distributing over 158 tons of subsidized fertilizers costing Ksh. 40 million (US$ 333)to over 200,000 registerd farmers. Other subsidized inputs are certified seeds with regard to Siaya zoning agroecologically. “Tractor for hire” where, the County Government has introduced around seventeen (17) tractors hired by the residents at a subsidized cost of Ksh. 2000. These subsidies measures are projected to increase land under cultivation to about 3000 acres an increase production to around 280, 000 bags averagely 18 bags per acre maize production (GoK, 2022).

Agricultural subsidies therefore are a measure in Siaya County through agro ecologically suitable seeds, fertilizers, and the increased land under cultivation to remedy the impact of climate change to improve food crop production. According to Hemmingway and Gunawan (2018), use of improved seeds, inorganic fertilizer and increased mechanization should be expected to increase agricultural productivity mainly in developing countries and for small scale farmers. So in this view, it is an expectation of the respondents that their production will increase and last for longer period pending another season of farming hence bridging the gap of food insecurity that has always been as a result of extreme weather conditions. However, the study learnt that access to these subsidised inputs was a concern. The study revealed that some of these inputs such as the tractors were not adequate to serve all the respondents in a given time hence delaying farming activities against the availability of rains in a season.

5.2.3.2 Social safety nets in Siaya County

In Siaya County, there are a range of social safety nets activities for the households such as cash transfer for the elderly, work for food by youth and women, supplemental feeding programs and Kenya national safety program "Inau Jamii" program for the elderly and most vulnerable in the community. Figure 5.3 results show that 9% (35) of the household respondents in the study area related social safety nets to the management of residual risks from the effects of climate change. Additional analysis to test the level of significance of the social safety nets practices was done. From the inferential statistical analysis, a Chi – square result of ($\chi^2_{5,0.05}$ = 19.10) with p-value of 0.045 at ($P<0.05$) was generated indicating a low statistical significance on the engagement of the households with the social safety nets in managing the residual risks from the effects of climate change in Siaya county.

Siaya County has experienced negative impacts of climate change that has reduced their capability to produce adequate and food safe for all and at all times hence increased chances of food insecurity risk of hunger and mulnutrition in the study area. According to Shaheen *et al*.,(2023), social safety nets have then over the years become ideal to communities all over the world in where Kenya has become a pioneer in Africa in establishing evidence based social protection mainly to protect most vulnerable households to effects of climate change. The study established that there exists a number of social safety nets in Siaya County. Through Kenya National Safety Net Program (KNSNP), "Inua Jamii" the poor elderly members of the community are covered by this program. This is a strategy to help the poor elderly people who do not have the capacity to farm for themselves and are vulnerable to the effects of the changing climate like flood, drought and heat stress and the resultant consequences of the extreme weather conditions like food insecurity.

The study also observed participation of members of the community and mostly the youth and women in community public works. This mainly entailed participation in access road network clearing of the bushes and drainages. From this activities, the study learnt that those who were involved expected to either be given food such as the maize and beans or be given money to go and purchace food of their preference. This program too, was to support the poor households from food insecurity that was as a result of negative impacts of climate change in Siaya County.

School feeding program was the third identified social safety net program in Siaya County. The program mostly implemented in the lower levels of basic education such as in Primary schools are meant to feed the children from poor households that can not afford food on daily basis. The study revealed that the program has been a game changer to the children from poor households mainly due to the impact of drought and floods. However, the study observed that there was need for the National government and County government to work closely with other private entities to strengthen the program to avoid delay in disbursment of the funds and increase the spectrum of of beneficiaries. This was supported by Rahmato (2013) that however much positive effects the social safety nets have had in communities, there was need to address some of the challenges such as proper identification of the beneficiaries and also widening the spectrum of the beneficiaries to significantly cover considerable households in managing the residual risks as in the case of Siaya county.

5.2.3.3: Food crop insurance in Siaya County

Crop insurance is a form of tranfering the risks that which is formally done between individual farmers and the insuring companies with the objective of normalizing the agricultural activities after an impact from the extreme climatic conditions (GoK, 2021b). Siaya County is one the 29 Counties in Kenya that have benefited from the 117 million insurance payout for small scale farmers. Figure 5.3 shows that 37% (143) of the household respondents in the study area related food crop insurance practice in managing residual risk from the effects of climate change in the study area. Inferential statistics analysis to test the level of significance of the crop insurance practives displayed a Chi – a square result of ($\chi^2_{5,0.05}$ = 11.23) with p-value of 0.05 at (P=0.05). Analysis therefore shows that there is low statistical significance of the practices of crop insurance in managing the residual risks from the negative impacts of climate change in Siaya County.

The study established that the crop insurance program was a patnership between the government, county government and the APA insurance company (GoK, 2021b) and has the aim of compensating the individual farmers that have lost crops in the 29 Counties in Kenya, Siaya included. Additionally, in 2020, the government of Kenya developed a policy on insurance of agriculture. This was mainly with regard to the continous effects and vulnerability of the agricultural lands to droughts, floods and pests together with diseases. The policy was aimed at financing compensation to farmers who are affected by the extreme climatic conditions and ensure resilient livelihood and strenthen food security systems through access. According to GoK (2021b), agricultural insurance is one of the coherent ways of derisking the agricultural sector and reducing vulnerability to farmers.

Agricultural insurance can significantly increase growth and development by trasfering risks and vulnerabilities from the agricultrural systems. However, According to key informants in the Ministry of Agriculture, the plan to insure agriculture still faces great challenges. Some of the challenges identified were from the insurers involving relactancy by the companies to provide cover to farmers that are mainly vulnerable to catastrophic events like drought, floods and pests together with the diseases. It was established that the reluctancy is due to the lack of capacity by the companies to underwrite the risks associated with the catastrophic risks.

Additionally, climate change negative effects may continue to affect the small scale farmers due to the low uptake rate by the farmers of the insurance policies. This was found out from the FGDs that majority of the participants indicated that due to poverty they were not able to afford the cover. Hence it was evident that majority of the respondents relied on or hoped for the pilot insurance cover that was not sufficient for the large number of the small scale farmers vulnerable to the climate change impacts.

5.2.3.4 Contingency funds in Siaya County

Contigency funds are mainly an allocation of funds by either the national government or the county government or any other organization such as NGOs and CBOs in anticipation of harmful events such as hunger, diseases and mulnutrition from the extreme climatic events like drought and floods such as in Siaya County (Schneider, 2010). Figure 5.3 indicate that 2% of the household respondents related the contigency funds access to the management of residual risk from the negative impacts of climate change in the study area. Inferential statistics analysis to test the level of significance of the access of the contigency funds by the households scored a Chi – square result of ($\chi^2_{5,0.05}$ = 19.10) with p-value of 0.09 at (P>0.05) indicating lack of statistical significance for access of the contingency funds in managing the residual risk from the effects of climate change in Siaya County.

The study established that the contigency funds were intended to aid the affected meet expenses that they had not forseen. For example, farmers to catter for the expense of buying food to avoid hunger after their expected harvest is negatively impacted on by droughts and floods in the changing climate. This view is supported by Schneider (2010), that the primary purpose of a contingency fund is to provide a financial safety net, helping individuals and families avoid going into debt or facing severe financial strain when unexpected situations like extreme climatic conditions such as floods, droughts pests and dieases arise.

According to GoK (2022), Siaya County government in previous financial years have allocated contigency funds towards floods and drought impact management. The contigency funds by the County government were meant to lead in mitigation of the climate extreme impacts, however, the study established that the initiative exhibited certain challenges with the allocation occasioned by the poor working relationship between the executive and the county assembly. This has been evident on many ocassions where the county assembly has failed to approve the budgets regarding contigency funds hence leading to lack of or limited access to the funds by the households to manage the residual risks after the negative impact of climate change on the agricultural production hence making the households more vulnerable to food insecurity.

The study additionally established that majority of the respondents had no idea about the contigency funds by the County government on extreme climatic change emergencies. It was found out that even if the funds existed, they were never used as had been planned for mitigating effects of the climatic events on agricultural production in Siaya County. Relatively, the participants indicated possibility of the funds being allocated but get diverted to other activities as predictability of the climatic events remain irregular or just lack of priority to disaster risk reduction in the context of food security enhancement.

5.2.4: Community – based disaster risk management approach in Siaya County

This section analyses and discusses activities under the community based disaster risk management approach such as a) prediction of hazards, b) implementation of the risk reduction activities, c) mornitoring of the implementation of the risk reduction activities, d) planning of the risk reduction activities and e) risk analysis from the results as presented in Figure 5.4. The results show that majority of the household respondents 47% (181) had participated in prediction of hazards in the community, followed by 34% (131) who had participated in implementation of the risk reduction activities, 11% (42) had participated in mornitoring of the implementation of the risk reduction activities, 7% (27) had been involved in planning of the risk reduction activities, while 1% (4) had been involved in risk analysis in the study area.

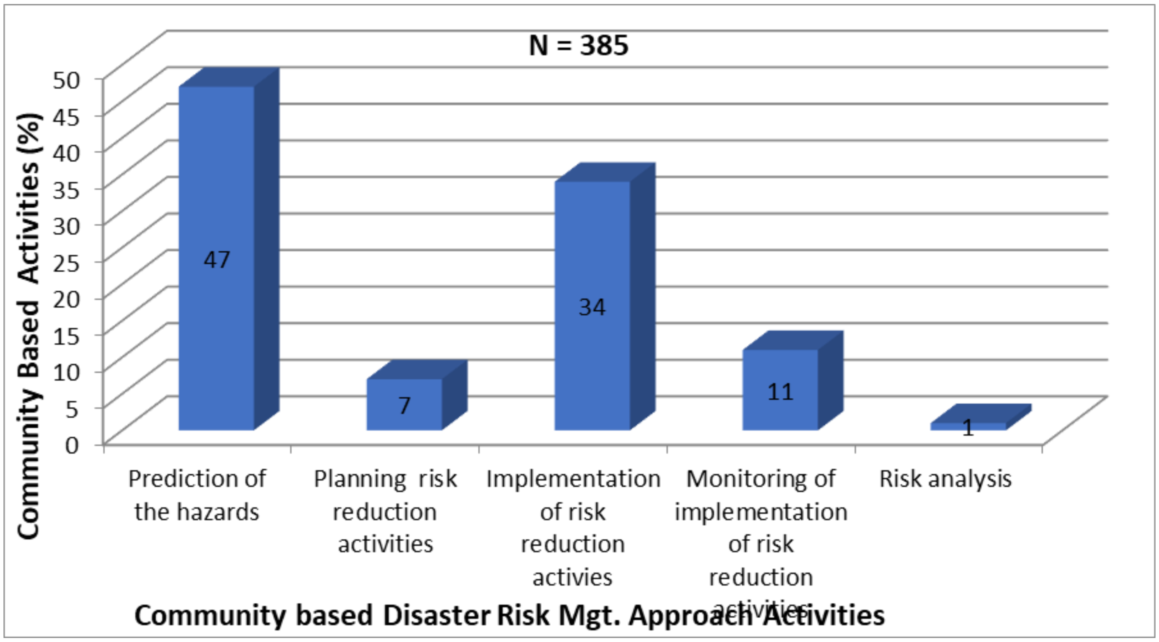

Figure 5.4: Community – based disaster risk management approach activities in Siaya County

Source: Field data (2023)

5.2.4.1: Prediction of the hazards in Siaya County

The study established that among the indigenous ways which the respondents used to predict climatic events were through animals, bird’s movement, insect behavior and existence in numbers. Additionally, observation of star pattern at night, direction of movement of wind and clouds, weekly chief's meetings "Barazas" were used by the respondents. Mainstream media through local radio station such as Radio "Nam Lolwe", Radio "Tembea" and "Dala" FM were mainly used in discussing current atmospheric status and possible occurrences of climatic related hazardous events on food crop in Siaya County.

Results in Figure 5.4 show that 47% (181) of the household respondents related their participation in prediction of hazards in mitigation of possible negative impacts from climate related hazards such as floods, droughts and pests and diseases in the study area. This descriptive analysis was then complemented with inferential statistical analysis to test the level of significance of community participation in prediction of hazards. A Chi – square test result ($\chi^2_{6,0.05}$ = 37.11) with p-value of 0.008 at (P>0.05) was generated indicating high statistical significance in participation of the households in prediction of the climate related hazards that may potentially impact negatively on agriculture in Siaya County.

The results show that majority (47%) of the respondents stipulated that they had been involved to a greater extent in prediction of the hazards that are related to climate change and mainly floods, droughts and pests and diseases. According to Yonder *et al*., (2021), it is important to engage the community in generating information by themselves and for themselves that can be very critical in providing regular updates on the climatic hazards and seasons towards agricultural production protection from climatic disaster negative impacts. From the field, the study ascertained that the involvement of the respondents in the prediction of the hazards was mainly through indigenous methods.

Based on the indigenous knowledge, majority of the respondents interviewed disclosed that they have always participated in predicting the climatic events. It was established that their views were mainly sought for during the local administration chief weekly meetings “baraza” on the likely changes that may occur that are climate related either in short term or long-term. These were coupled with the views on the level or possible magnitude the climatic events could cause to the agricultural production and mainly crop production in the study area.

On the other hand, it was established that the respondents also used mainstream media such as the vernacular stations. The stations were mainly used to give their input based on indigenous knowledge that may help in prediction of possible flood, drought and pest invasion. According to Kagunyu (2016) platforms such as local radio are easily accessible by the community and are mostly used for communication on climate related hazardous events. The study hence observed that this might have contributed to the high percentage of respondents who indicated that they had been involved in prediction compared to the other community-based risk management activities in mitigating climate related risks on agricultural production in Siaya County.

5.2.4.2 Climatic risks analysis in Siaya County

Climate risk analysis provides an assessment of the possible interaction of the various climatic hazards with the socio-economic factors in order to determine the likely negative impact on the various elements in the context of livelihoods such as subsistence agriculture (GoK, 2019). Descriptive analyses in Figure 5.4 show that 1% (4) of the household respondents had participated in climatic risk analysis in managing possible negative impacts of climate related hazards on agricultural production in the study area. Additionally, an inferential statistics analysis to test significance level of the household participation in risk analysis towards climatic risk mitigation was conducted. Analyses show a Chi – square test result of ($\chi^2_{6,0.05}$ = 41.23) with p-value of 0.10 at (P>0.05) was generated indicating lack of statistical significance of the household participation on climatic risk analysis in mitigation of the possible climate change negative impacts in Siaya County.

It was established that through risk analysis, the populations have a chance to make positive decisions that promote sustainability by reducing vulnerability to the elements that are associated to climatic risks. According to Hellmuth *et al*., (2007) climatic risk analysis which is an integral part of climatic risk management provides an approach on maximizing positive and minimizing negative outcomes for communities in areas of agriculture and food security.

The study established that in Siaya County there was very little participation of members of the community on climatic risk analysis. From the study, some of the organizations involved in climatic risk reduction activities were CARITAS, Kenya Climate Smart Agriculture Project (KCSAP), "Tembea" Youth for Sustainable Development as CBO and the County Government through disaster management committee. These organizations engage the community in identifying and analyzing potential elements such as food crop farms and storage facilities that were at risk and vulnerable to the extreme climatic conditions in various areas and time within the study area.

It is evident that there is very little involvement of the local community in the climate risk analysis where participants in the focus group discussion had the opinion that lack of information had contributed to the lack of participation. This establishment resonates with Sufri *et al*., (2020), where the researcher found out that one of the factors that significantly affected people's participation in community capacity building efforts is lack of awareness. Other participants also pointed out that the levels of engagement in the discussions about the risks are higher where the concerned only involve a clique of people in the society that are perceived to understand issues of climate change than the rest of the community members.

5.2.4.3 Planning risk reduction activities in Siaya County

The study established lack of consensus with regard to the existing forums level of participation in planning of the risk reduction activities. According to a key informant, a member of the County disaster committee, forums had been created through workshops about the needed participation of the people in planning risk reduction activities. However, participants in the Focus Group Discussion had contrary views indicating that there was lack of or insufficient information to the majority of the community members about their intended roles and responsibilities in planning for community risk reduction activities hence making none participation.

Figure 5.4 shows that only 7% (27) of the household respondents related their participation in planning risk reduction activities to the mitigation of the climate related risks under the changing climate in the study area. To test the level of significance of the household participation in planning of the risk reduction activities, an inferential statistics analysis was conducted. Results from a Chi – square test ($\chi^2_{6,0.05}$ = 48.09) with p-value of 0.08 at (P>0.05) was generated that indicated lack of statistical significance of the household participation in planning of the risk reduction activities in managing the climate related risks on crop production in Siaya County.

The community is expected to be actively involved based on their experiences on climate change and negative impact on agriculture. However, the study established that there was little participation by the household respondents in planning of the risk reduction activities. Based on an action plan, a strategy can be developed outlining various activities based on the available resources to achieve climate risk reduction and enhancement of food security. Supported by (Lakeman and Lakeman, 2022), risk reduction action plan is a method that should involve local stakeholders including the members of the community to consult and develop consensual risk reduction strategy resilience on vulnerable sectors such as agriculture and water.

5.2.4.4 Implementation of risk reduction activities in Siaya County

The study sought to establish the level of participation of the respondents on community-based disaster risk management and results in Figure 5.4 show that 34% (131) of the household respondents had participated and related their participation in implementation of risk reduction activities to the management of climate related risks such as floods and droughts in the study area. Additionally, the study tested the level of significance of the household respondent’s participation in implementation of risk reduction activities.

Inferential statistics analysis results from a Chi – square test ($\chi^2_{6,0.05}$ = 18.02) with p-value of 0.03 at (P<0.05) showed that there was a statistical significance of the household respondents' participation in implementation of the risk reduction activities in mitigating the negative impacts of the climate related disaster such as floods and droughts in Siaya county.

The study established that most of the risk reduction activities that the respondents took part in implementing comprised of those influenced by the various organizations regarding climate change resilience and food security in Siaya County. Such organizations included Dorcas International, Kenya Climate Smart Agriculture Project and Care Kenya International Organization, working on strengthening Resilience on Climate Change Project operated in Siaya County where majority of the respondents participated in implementation of risk reduction activities such as planting drought tolerant crops, rearing drought tolerant livestock, crop diversification and rotational cropping. The results from this study agree with Samaddar *et al*., (2021) on the successful community participation in climate change adaptation programs that affirmed that community participation on the implementation of the risk reduction activities through organizations working with the communities had increased with time. However, the study pointed out various challenges such as little understanding and consensus on how and to what extent local communities should be involved by the implementing organizations.

The study established that the projects fostered the development of County government sustainable climate change governance structures, policies and financing mechanism that would ensure effective inclusion and participation of the community and other stakeholders towards a built resilience. However, the study found out that there are various individual efforts by the respondents related to risk reduction activities. Some of these activities comprised of reducing the number of livestock kept by the households from drought effect; planting crops that mature faster in the short rains seasons in possible flood locations and considering conservation agriculture practices such as mulching in their individual farms.

5.2.4.5 Monitoring of implementation of the risk reduction activities in Siaya County

To establish the level of participation of the household respondents in monitoring the implementation of the risk reduction activities, the study conducted a descriptive analysis and results in Figure 5.4 show that 11% (42) had participated and related their participation in monitoring with mitigation of disaster risks from the effects of the changing climate in the study area. To test the level of significance of the household respondents in monitoring to risk reduction, an inferential statistical analysis displayed a Chi – square test results ($\chi^2_{6,0.05}$ = 18.02) with p-value of 0.15 at ($P>0.05$) indicating a non-statistical significance in household respondents participation in monitoring towards mitigation of the risks related to climate change in Siaya County.

Monitoring of the implementation of risk reduction activities by the population was lowly ranked by the respondents in Siaya County. The result therefore reveals that very few of the respondents are involved in monitoring exercise of the implementation of the risk reduction activities in the study area by the implementing or funding organizations. However according to Hemingway and Gunawan (2018), to make it possible to control the progress of any given project according to the plans within the community and to achieve the desired results, monitoring is critical.

The study therefore established that most organizations do not involve the respondents in the monitoring and those who involved the community members did so as a form of compliance towards accountability to the project implementation process. According to Kabesiime *et al*., 2015) monitoring should not be just an event but rather be an ongoing process that should have the capacity to improve collaboration and working relationship between the community and the implementing organizations and the authorities.

The study established that there was low key participatory monitoring in implementation of the risk reduction activities in Siaya County. Some of the factors that affected participatory monitoring of the projects where, lack of empowerment of the locals to effectively participate in monitoring. The study revealed that this was characterized by none or little knowledge, training and skills on the process of monitoring of the implementation of the risk reduction activities by the community members.

5.3. Relationship between the Disaster risk management Approaches and climate change in Siaya County

The study sought to establish the association between the Disaster risk management approaches and climate change. The study used climate change effects to test how the respondents related the disaster risk management approaches to the changing climate. Results in Table 5.1 shows that Prospective disaster risk management approach has a positive though weak relationship $r = 0.21$ giving a low significance p – value 0.044 ($P<0.05$); Corrective disaster risk management approach indicating a stronger positive relationship $r = 0.95$ giving a high significance value p – value 0.001 ($p < 0.05$); Compensatory disaster risk management approach, indicating a weak positive correlation $r = 0.002$ with a none significant value $p = 0.52$ ($p > 0.5$); while Community based

Disaster risk management approach also indicated a positive but a weak correlation r = 0.692 with a significance value $p = 0.031$ ($p < 0.05$).

Table 5. 1: Correlations between the Disaster risk management approaches and climate change in Siaya County

		Effects of climate change	Prospective DRMA	Corrective DRMA	Compensatory DRMA	Community Based DRMA
Effects of climate change	Pearson Correlation	1	.021	.957	.002	.692
	Sig. (2-tailed)		.044	.001	.052	.031
	N	385	385	385	385	385
Prospective DRMA	Pearson Correlation	.021	1	.062	-.052	-.010
	Sig. (2-tailed)	.044		.228	.310	.845
	N	385	385	385	385	385
Corrective DRMA	Pearson Correlation	.957	.062	1	.032	-.001
	Sig. (2-tailed)	.001	.228		.535	.981
	N	385	385	385	385	385
Compensatory DRMA	Pearson Correlation	.002	-.052	.032	1	.046
	Sig. (2-tailed)	.052	.310	.535		.366
	N	385	385	385	385	385
Community Based DRMA	Pearson Correlation	.692	-.010	-.001	.046	1
	Sig. (2-tailed)	.031	.845	.981	.366	
	N	385	385	385	385	385

Source: Field data (2023)

The analysis therefore reveals that all the disaster risk management approaches in Siaya County are related to climate change. However, there are those that are more related with respect to their significance in management of the climatic hazards and risks. In this regard, Corrective disaster risk management ranked highest in significance followed by Community based then Prospective and last Compensatory disaster risk management approach.

CHAPTER SIX

RELATIONSHIP BETWEEN CLIMATE TRENDS AND FOOD CROP PRODUCTION IN SIAYA COUNTY

6.1: Introduction

This chapter presents results and discusses findings of the objective (ii) of the study; which is; to determine the relationship between climate trends and food crop production in Siaya County. This chapter is divided into sub sections as a) characteristics of climate in the study area, b) climate trends, c) food crop production trends and d) the relationship between climate trends and food crop production.

6.2: Characteristics of climate in Siaya County

6.2.1: Climatic hazards mostly experienced in Siaya County

This section analyses and discusses the common climatic hazards experienced in the study area and the results are presented in Figure 6.1.

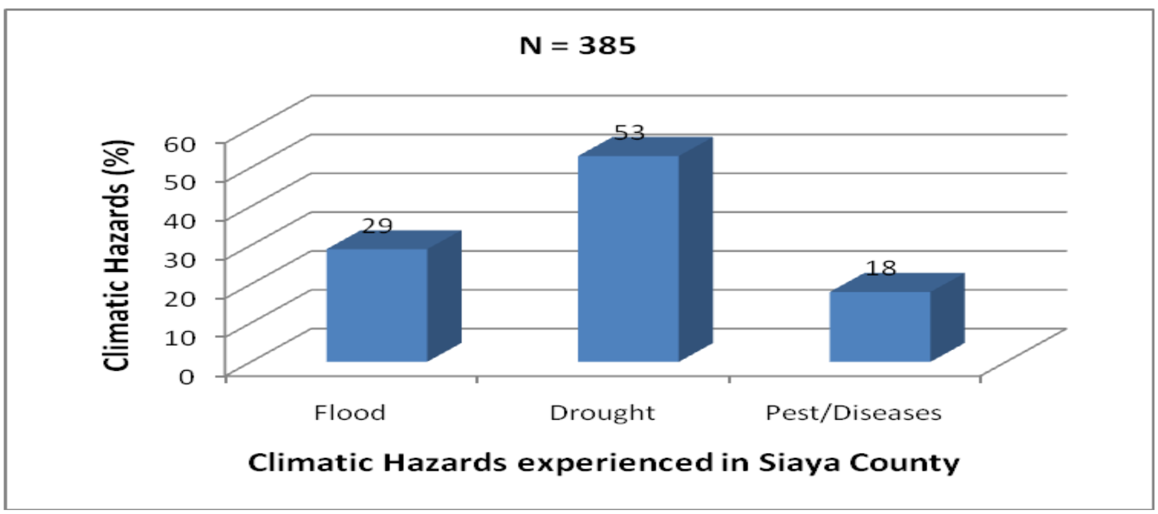

Figure 6.1: Climatic hazards in the study area

Source: Field data (2023)

Results in Figure 6.1 show that majority 53% (204) of the household respondents had experienced droughts in the study area. According to MoALF (2016) drought is a normal occurrence in Siaya County where lowland areas around Lake Victoria are mostly affected. These areas comprise of sub counties such as Bondo, Rarieda and parts of Alego Usonga characterized as LM3, LM4 and LM5 in the Agro Ecological Zones in Siaya County. It means that out of the six sub counties, three in the study area accounting for 50% of the County experiencing drought.

Flood was ranked second at 29% (112) among the climatic hazards in Siaya County by the respondents. The study established that floods in Siaya County are mainly as a result of intense and frequent rains and the riverine water which stretch the capacity of the channel to contain a given amount at a given time. Therefore, it is worth noting that the areas that mostly experience floods in Siaya County are areas that have close proximity to the river banks of River Yala and River Nzoia. However, the study established that there are areas in Siaya County that experience both floods and drought given their proximity to Lake Victoria and mainly at the low lands receiving excess water from the uplands such as in Alego Usonga, Rarieda and Bondo Sub Counties. Other areas like Gem, Ugenya and Ugunja are in the highlands which receive higher amount of rainfall 2280 mm than the rest of the Sub Counties and a temperature of 21.4 degrees Celsius hence do not experience extreme drought (Gok, 2022). Additionally, their geographical terrains do not allow for floods to occur in those areas but the effect is just realized at the low lands.

Lastly, 18% (69) had experienced pests and diseases due to climate change in the study area. Pests and diseases were identified among the hazards based on the fact that climate change influences to a greater extent the existence and occurrence of the pests such as locusts, stalk borer and army worms and certain diseases such as leaf blight in dominant crops of maize, sorghum, beans and cassava. According to FAO (2021), climate change will continue to increase the risk of pests spreading in both the agricultural ecosystems especially in the temperate and subtropical regions like Siaya County. It is then believed that an area that is usually warm or of moderate temperature may assist the establishment, multiplication and spread of any invasive pests and pest causing diseases. The study established that among the areas that have experienced pest invasion and increased cases of crop diseases are Nyamila in North Alego, Yimbo in East Bondo and some parts of Ugenya Sub County of Siaya County.

6.3: Climate trends in Siaya County

This section analyses and discusses results in accordance to objective (iii) to establish the climate trends and it involved analysis of a) Rainfall and Temperature trends, b) flood occurrence c) drought occurrence in the study area.

6.3.1: Rainfall and Temperature trends in Siaya County

Time series analysis was done using MS Excel software package whereas the Mann-Kendal test was applied to determine the trends significance and correlation coefficients of the two climatic parameters. The measurable variables were time (Years) against annual rainfall (mm) and of Temperature (° C) over the period (1992 -2021) as presented in Appendix IV and V. Analysis in Figure 6.2 show the trend of average temperature in the study area with the year 2020 experiencing the lowest at 27.6°C, the year 2007 highest at 28.8°C, with the mean temperature of 28.2°C and with a standard deviation of 0.296983°C.

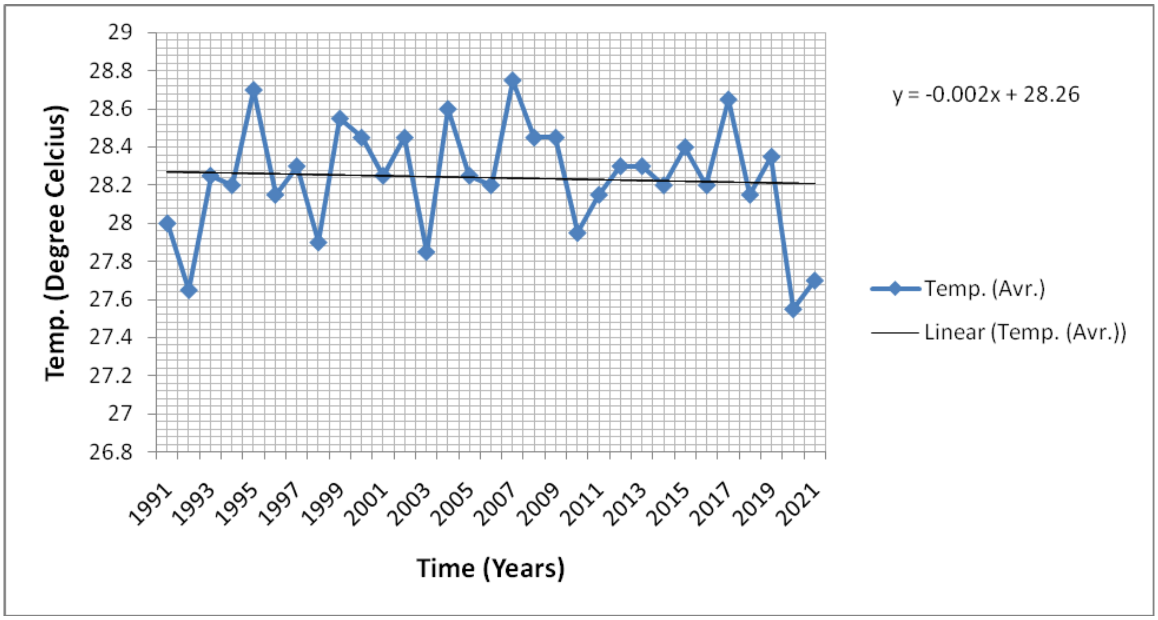

Figure 6.2: Temperature trend in Siaya County

Source: Kenya Meteorological Department, Siaya (2023)

The Mann-Kendall analysis was done to establish the trend in the annual average temperatures in the study area under the period of study (1991 - 2021). Results in Table 6.2 displayed an S value, tau value and p – value. The S was computed for a statistic test to assess the presence of trend in the time series data. Results show that S had a value of 14.00. Analysis therefore shows that there was an upward trend in the temperatures in the study area. Secondly, the study also conducted a tau test to measure the strength and direction of association between Temperature (°C) and time (years) in the study area. Result of τ value = -0.031 was displayed and the analysis therefore showed that there was weak increasing trend of temperature in the study area. Lastly, p- value analysis was done to test if the observed trend was statistical significant. The results indicated a p – value of 0.82 > 0.05 showing that there was no statistical significance in the observed trends of temperature in Siaya county.

Table 6.2: Mann-Kendall test on the trend of temperature in Siaya County

	S	Tau	VarS	p-value	Result Interpretation
Temp.(°C) trend	14.00	-0.0308	3433.33	0.8244	Reject Hypothesis

Source: Field data (2023)

Studies have shown that there is an increasing trend in Temperature in Siaya County. Abura *et al*., (2017) in a study observed increase in temperature in Siaya County however, it lacked significant trends but had a characteristic that showed variations in temperatures over the years 1986 to 2015. In the larger Lake Victoria basin within which Siaya County is located, findings from related studies on temperature and rainfall trends by Olaka *et al.*, (2019) have confirmed that there is an increasing projection of temperature. The analysis therefore shows that there was increase in average temperature in the study area however the increase was not statistically significant.

6.3.1.2: Rainfall trends in Siaya County

Figure 6.3 shows the trend of annual rainfall from 1992 – 2021. Within that period, the time series analysis identified the minimum annual rainfal amount in the study area as 1133.79 mm in the year 2016, a maximum rainfall amount of 2684.19 mm in the year 2020 and a mean annual rainfall amount of 1737.94 mm with a standard deviation of 374.03 mm in Siaya County.

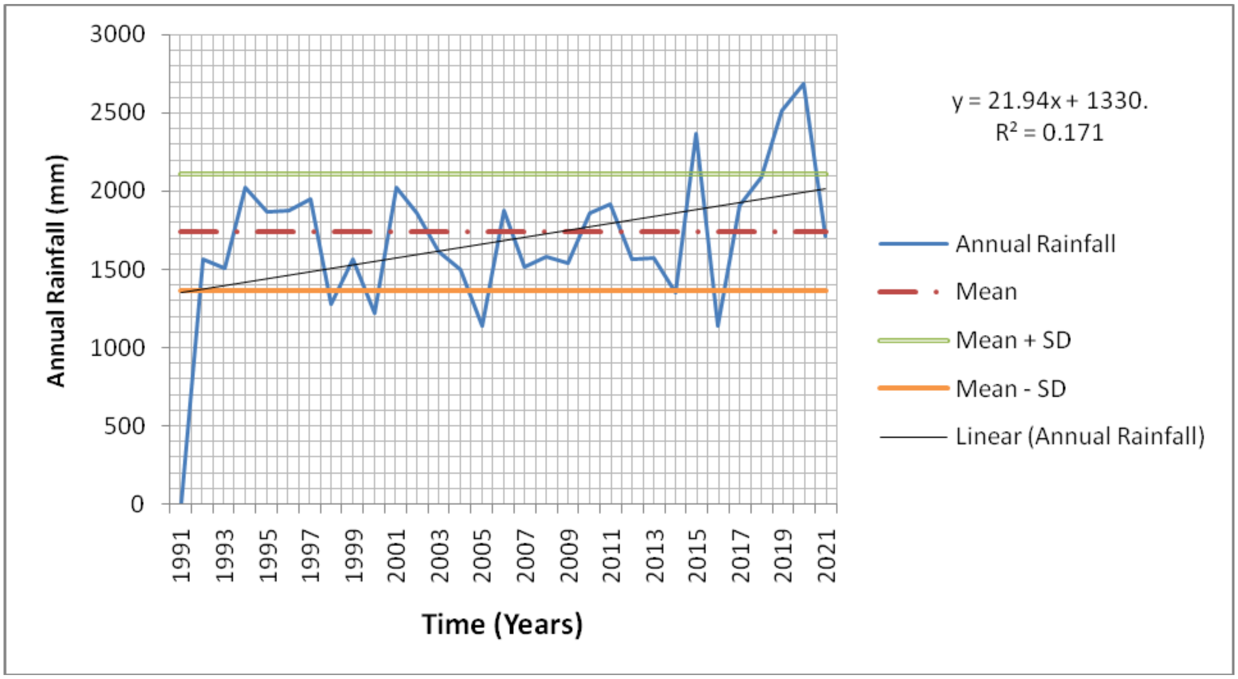

Figure 6.3: Rainfall trend in Siaya County

Source: Kenya Meteorological Department, Siaya County (2023)

In order to profile the years that received higher and low amount of rainfall that could have resulted into flooding or drought conditions, time series analysis was conducted as presented in Figure 6.3. These were classified into below normal < (mean-SD), years that had received low amount of rainfall leading to drought conditions, normal which was between (mean-SD and mean + SD), and above normal > (mean + SD) conditions based on the Kenya Meteorological Department (KMD) convention (Mugalavai and Kipkorir, 2015). Using one standard deviation as appoint of reference, the region above (mean + SD) indicated years that received higher amount of rainfall. Rainfall data analysis for the period under consideration (1991 – 2021) show that there was possibility of drought occurrence in 1991, 1998, 2000, 2005, 2014 and 2016 based on the fact that their annual rainfall amount was below the normal, while years that might have experienced floods are 2015, 2018, 2019 and 2020 basing on the higher annual amount of rainfall that was received being above normal in Siaya County. The normal annual rainfall years fall between the (mean + SD) and (mean – SD) considering the period under investigation.

The study further conducted a Mann-Kendall test analysis to establish the trend of annual rainfall in the study area for the period under the study (1991 – 2021). Table 6.4 indicated an S value of 69.00, the analysis therefore showed that there was an observable increasing upward trend of annual rainfall amount received in the study area. Additionally, the results indicated tau value, $\tau = 0.159$. This therefore shows that there was a weak increasing trend of rainfall amount received annually in the study area. Lastly, a p – value of 0.23, $P > 0.05$ thresholds was displayed. Analysis hence shows that there is no statistical significance in the observed increasing trend in the annual rainfall received in Siaya County.

Table 6.4: Mann-Kendall test on the trend of rainfall in Siaya County

	S	**tau**	**VarS**	**p-value**	**Result Interpretation**
Rainfall trends	69.00	0.159	3141.67	0.2251	Reject Hypothesis

Source: Field data (2023)

The results revealed lack of statistical significance in the increasing trends of annual rainfall for the period (1991 – 2021) hence is rejecting the hypothesis. This study resonates with Wabwire *et al*. (2020) findings which established that rainfall extremes have become frequent and there is a general increase in the trends however indicating no statistical significance in Lake Victoria Basin. However, Ogega (2020) also observed that there had been increased amount of rainfall received within the Lake Victoria Basin that was attributed to the changing climate hence leading to increased levels of water in Lake Victoria over the years.

6.4: Flood trends in Siaya County

Analyses under flood occurrence were based on probability of exceedance and flood frequency using annual rainfall data.

6.4.1: Flood probability of exceedance using rainfall data in Siaya County

Probability of exceedance analysis was conducted and the results in Figure 6.4 indicate that at an interval of 10, 2246.8 mm had a 10% probability of exceedance, 2076.04 mm - 20%, 1946mm - 30%, 1838.4 mm - 40%, 1737.95 mm - 50%, 1637.53 mm - 60%, 1529.90 mm - 70%, 1403.87 mm – 80% while 1229.07 mm displayed a 90% probability of exceedance.

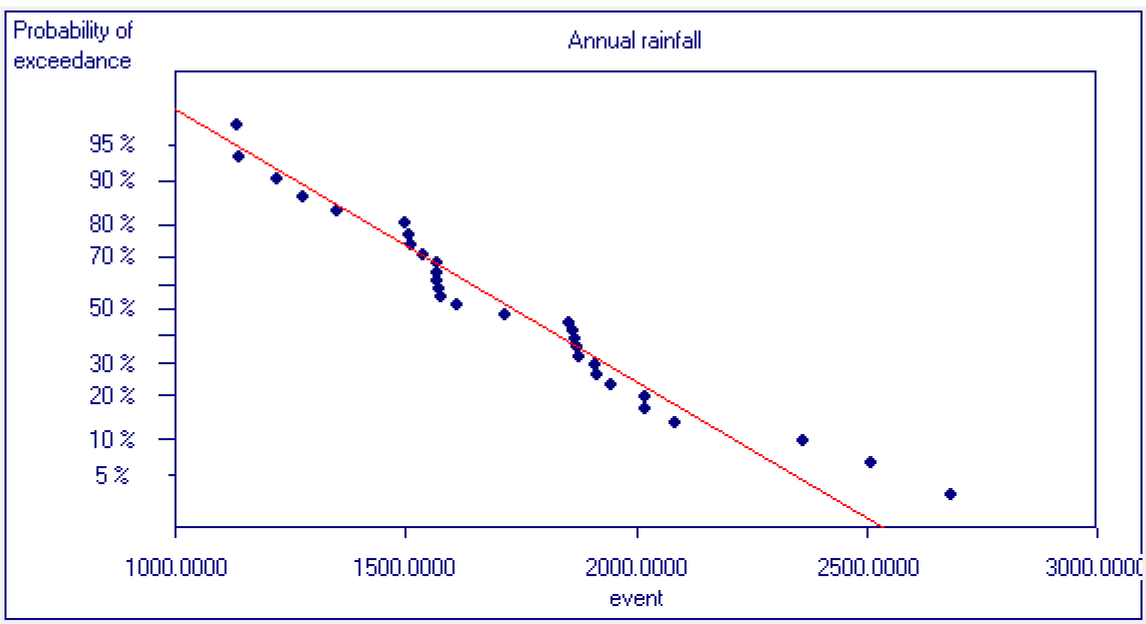

Figure 6.4: Probability of exceedance of floods in Siaya County

Source: Field data (2023)

In relation to the mean annual rainfall for the period (1991 – 2021), that was 1737.95 mm in Siaya County, the analysis therefore showed that floods in the study area had a 50% probability of exceedance which at the 95% confidence level translates to 0.05, p value = 0.05. Analysis therefore indicated that there was a positive association between annual rainfall amount and flood occurrence however, it was of low significance in Siaya County. The analysis further showed that there has been a declining trend in flood probabilities in Siaya County as exhibited by the trend line and based on the time period under study. This was informed by the annual amount of rainfall giving a declining trend of probability with the probable increase in rainfall amount in the years. Probability of exceedance results to flood risk establishment that can be used to estimate its possible damages in a given environment in case of flood occurrence (Meyer, 2013). Therefore, the estimation of potential damages mainly on the agricultural systems may be used to make decisions and define policies aimed at reducing potential flood hazards on food crops and help improve of food crop production (FEMA, 2014).

6.4.1.1: Flood Frequency in Siaya County

A frequency analysis to test the return periods of floods occurrence was conducted using the probability of exceedance analysis. Results in Table 6.5 show that the probability of exceeding 2246.84 mm of rainfall is 10% (0.01) level of significance can only occur after every 10 years, 20% (0.02) may return after every 5 years, 30% (0.03) confidence level returns after every 3 years, 40% (0.04) confidence level gave a return period of 2.5 years, while 50% (0.05) confidence level which displays the average of the annual rainfall in the study area gave a return period after every 2 years while 60% (0.06) confidence level indicated a 1.7 return period, 70% (0.07) confidence level had a 1.4 years return period, 80% (0.08) had a 1.5 year return period while 90% with a confidence level of (0.09) displayed a 1.1 year return period in Siaya County.

Table 6.5: Flood frequency analysis using probability of exceedance and possible return periods in Siaya County

Probability of exceedance (%)	Return period (year)	event
10	10	2246.8436
20	5	2072.0412
30	3.33	1946.0012
40	2.50	1838.3781
50	2	1737.9553
60	1.67	1637.5325
70	1.43	1529.9094
80	1.25	1403.8695
90	1.11	1229.0670

Source: Field data (2023)

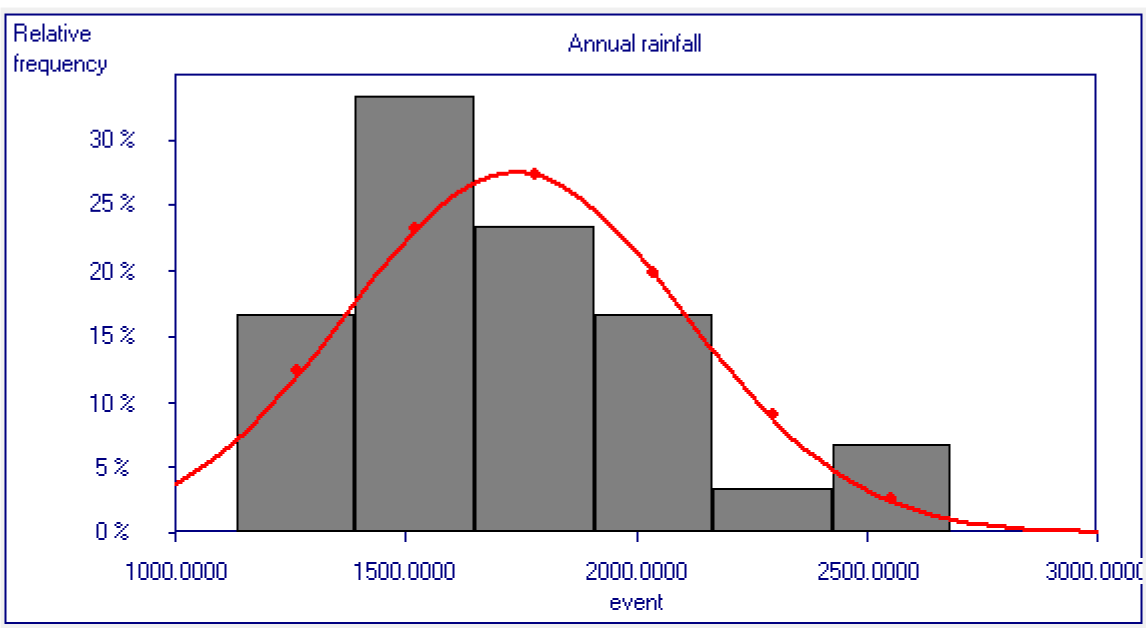

Figure 6.5: Flood frequency histogram for Siaya County

Source: Field data (2023)

In reference to Figure 6.5, analysis showed a normal distribution of the frequency under the period of study in the study area. From the distribution, it was observed that frequency of floods are low, normal and high. The normal distribution displays symmetry, indicating that as flood events move away from the average flood magnitude in both directions, their occurrence becomes less frequent. In the realm of flood frequency, this balance signifies that floods significantly smaller or larger than the average magnitude are less common. This is attributed to the dynamics of annual amount of rainfall received over the years as either increasing or decreasing within the study area.

The study established that floods occurrence in Siaya county was on an annual basis and mainly associated with the long rain season that basically occur in the Lake region is normally between March to May. Additionally, the study observed that it is during this time every year that floods are normally experienced in certain areas of the study area such as the low lands and the areas around the existing Rivers like Nzoia and Yala due to damages on the river banks or back flow of water when the water levels rices in Lake Victoria. This resonates with GoK (2022) on floods contigency plan, a focus on Nyadorera area which revealed that the flooding in Siaya County and parts of Busia as a neighbouring county are mainly as a result of heavy rainfall storms in the Nzoia basin in the long rains season of March, April and May that at the far end affects the livelihoods at the lower Nzoia communities.

6.4.2 Flood probability of exceedance using River gauge data (Nzoia and Yala) in Siaya County

The study established that both River Nzoia and Yala have a contribution to the occurrence and recurrence of floods in specific geographical locations along the two Rivers. The study established that within the period of study (1991-2021) the highest amount of discharge was mainly in 2020 at 650.27 m^3/s while the lowest was in 2008 with 2.81 m^3/s in River Nzoia. In River Yala, the highest discharge within the study period (1991-2021) was in 2016 with 337.44 m^3/s while the lowest was in 2009 at 9.17 m^3/s. Q represents the flow discharge of the Rivers where, Q 50 indicated the flood flow meaning the probability level at which water level would exceed and cause floods in both River Nzoia and River Yala, Q 80 indicated normal flow where water levels was within the capacity of the Rivers while Q 95 represented is the environmental flow indicating the probability of water reaching the lowest level where it should not be used for any other human activities other than for the physical environmental benefits.

According to the flow duration curve, the analysis showed that within the period of study, probability of exceedance that would lead to floods had a discharge of 130.1500 m^3/s translating to 11,244,960 m^3/day in River Nzoia. On the other hand, analysis for River Yala flow duration curve showed that the probability of exceedance was 71.4036 m^3/s that translated to 6169271.04 m^3/day as shown in Table 6.6 and Figures 6.6 and 6.7. According to Nabwire (2019), River Nzoia which has mainly affected the both Siaya and Busia Counties has an annual mean flow discharge of 1777 m^3/year however, this can be subject to the location of gauging where the data was acquired to make the difference either at the lower or upper Nzoia.

Table 6.6: Probability of flow exceedance in Rivers Nzoia and Yala in Siaya County

Percentage Exceedance	Discharge (m^3/s) River Nzoia	Discharge (m3/s) River Yala	m^3/day River Nzoia	m3/day River Yala
Q50 - Flood Flow	130.1500	71.4036	11,244,960	6,169,271.04
Q80 - Normal/ Design flow	68.9336	43.3177	5,955,863	3,742,649.28
Q95 - Environmental flow	24.503	21.7173	2,117,059	1,876,374.72
Allocatable Flood flow (Q50 - Q95)	**105.64700**	**49.6863**	**9,127,901**	4,292,896.32
Allocatable Normal flow (Q80 - Q95)	**44.43060**	**21.6004**	**3,838,804**	1,866,274.56

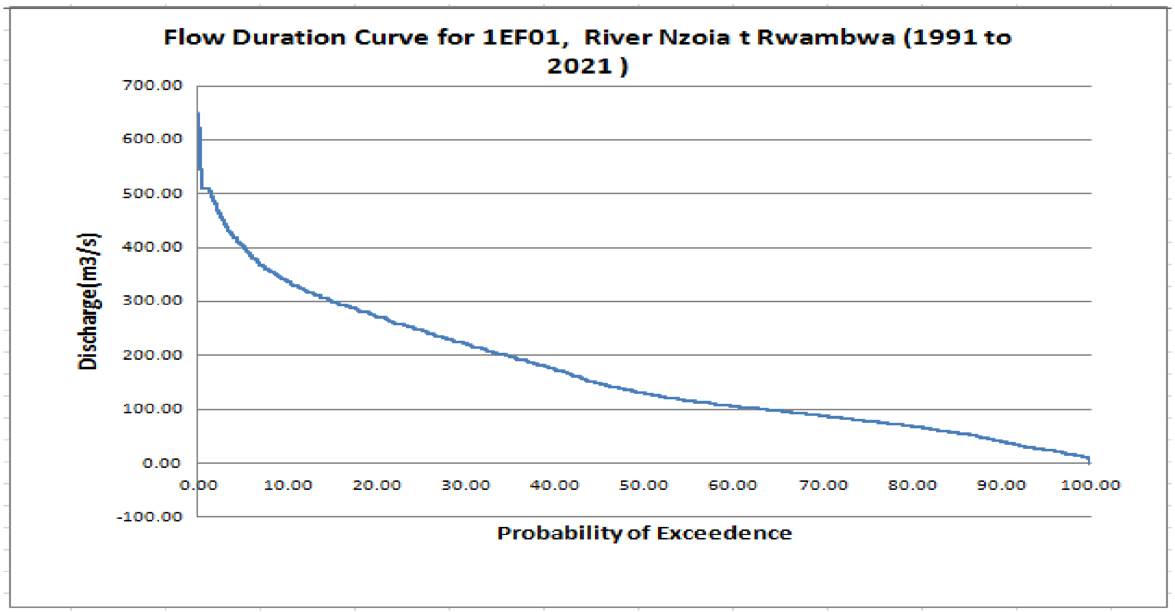

Figure 6.6: Probability of exceedance of River Nzoia flow discharge

Source: WRA (2023)

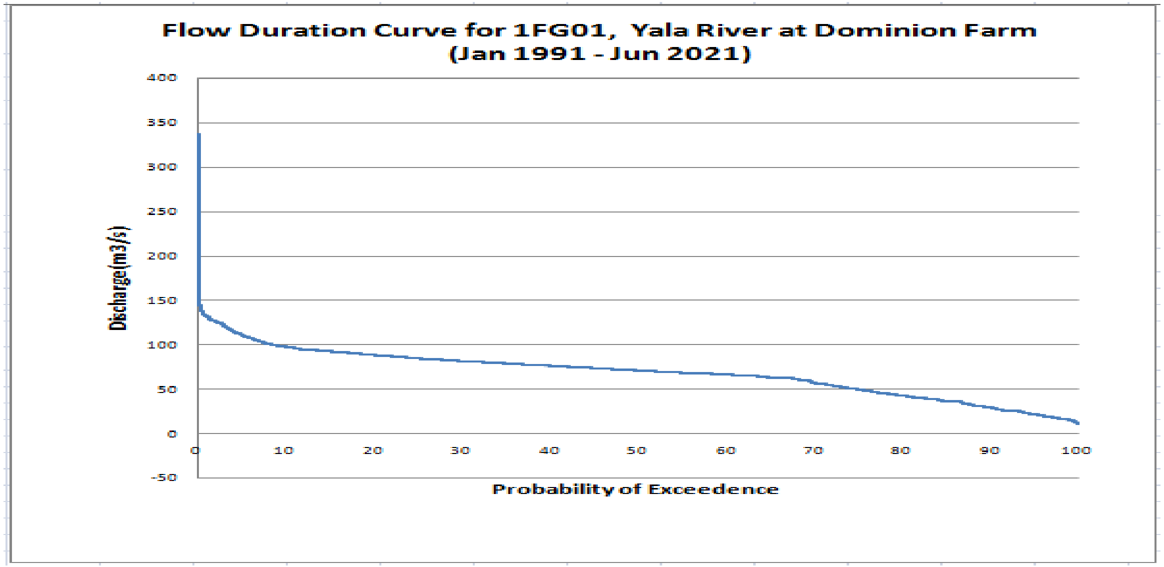

Figure 6.7: Probability of exceedance of River Yala flow discharge

Source: WRA (2023)

The probability of exceedance analysis therefore shows that in Siaya County, due to the changing climate, there have been variations in the water levels in the main Rivers as Nzoia and Yala have within the period of study. This implies that water levels have caused floods in the study area over the years hence impacting negatively on the livelihoods such as food crop farming hence total failure or reduced yields in the study area.

UNEP (2019) posits that flood prevalence in Kenya rates at about 27%, which leads to food disasters affecting over 5% of the populations livelihoods. This is supported by GoK (2022) that flood occurrence in Western Kenya which is partly of riverine nature that is mainly as a result of exceedence of stream flow capacity leading to breakage of the river banks hence spillage on to the flood plains. Some of the Rivers that have frequently caused floods in the Western Kenya are Kuja, Nyando, Yala, Nzoia and Sondu that have high frequency in occurrence than other parts of the country (Nabwire, 2019). According to MoALF (2016), food crops are equally affected by floods mainly from Rivers Nzoia and River Yala in addition to the negative effects of floods as a result of excessive rains in the main rainy seasons as March, April and May (MAM). Some of the parts of Siaya County that have been affected by floods from River Nzoia are Nyadorera in Alego Usonga Sub County.

6.4.2.1 Flood magnitude in Siaya County

Floods in the study area were rated highly as intense with regard to the negative impacts experienced by the study respondents on the agricultural systems from floods occurrence and recurrence. The study established that there were rapid damages with respect to occurrence and recurence of the floods on the agricultural farms. This means that, whenever the floods occurred, crops were affected more than the livestock. The study therefore concluded that based the magnitude and speed of the floods, increased amount of destruction was caused to agricultural production as compared to drought which has slow development. According to England and John (2018) the intensity of flood is measured by the damage it causes where, this also depends on the depth and volume of the floods which characterizes the velocity hence the the magnitude of damage on the crops and the general environment.

6.4.2.2 Floods duration during occurrence

Floods in Siaya County last for one month that was mainly in the month of May whenever it occurred. This is with regard to the analysis from the field and indication by the majority 89% (11) of the group respondents. The study confirmed that “MAM” season received long and heavy rains that in many occassions have caused flooding in the low land and the riverine environments of Siaya county. Relatively, the only possible time that the floods occured is during the long rains which happens ones a year. The study observed that within the long rains period, floods are never experienced in the first month of March but water from runoffs builds up towards the middle of second month April and floods are only realized between April and May for atmost one month.

The study established that in the low lands such as Alego Usonga and and part of Ugenya and Bondo sub counties floods lasted for three or more months. This was as a result of the geographical orientation which makes the water mostly from highlands to accumulate in the low lands of the study area that may take longer time to be absorbed into the ground. Floods occur in areas that have close proximity to water bodies or in areas which receive prolonged rainfall or that have poor drainage systems hence floods may occur in small geographical areas but with longer duration of time to recede (Hirabayashi *et al*., 2013).

According to Western Regional manager, Key informant from the Water Resource Authority:

> "We need to observe that the type of soil also determined the duration of time floods lasted where clay soil areas have the capacity to hold water for long hence longer duration of floods as opposed to area with other types of soil such as sandy soil".

This therefore means that it is possible that the areas where the floods lasted for more than one month had other determinants such as types of soil for example clay soil or were flat and caused water to stagnate for a longer period of time in Siaya County. This explanation resonates with Werner *et al*. (2006) that the time span between the start and the end of the flood is difficult to define given that they recede slowly and may not varnish completely but may move from one place to another.

6.5: Drought occurrence in Siaya County

Drought occurrence analysis was done to establish drought characteristics such as drought duration, intensity and probability of occurrence. Annual and Seasonal drought anomalies were analyzed to assess the possible effects and magnitude of drought on the growing seasons in the study area.

6.5.1: Annual drought index in Siaya County

Table 6.7 presents the annual standardized precipitation indices computed from the annual rainfall to analyze the annual drought index for the period (1991 – 2021) for Siaya County.

Table 6.7: Annual Standardized precipitation indices (SPI) for Siaya County

SN	Months	Standardized Precipitation Index (SPI)
1	January	-0.68
2	February	-0.95
3	March	0.33
4	April	1.35
5	May	1.00
6	June	-0.30
7	July	-0.73
8	August	-0.47
9	September	-0.07
10	October	0.33
11	November	0.53
12	December	-0.35

Source: Researcher (2024)

The study sought to establish the nature of drought on annual level. The results were important in monitoring the annual trends of drought that would also be used to test its cumulative effect to the annual food production of the dominant crops and trends in the study area. The Standardized Precipitation Index (SPI) is a widely used meteorological drought index that quantifies precipitation deficits over various time scales. This index provided a standardized way to assess and compare the severity of drought conditions, making it a valuable tool for drought monitoring in the study area. SPI was used to calculate the difference between the actual precipitation for the time period under study (1991 – 2021) and the long-term average precipitation for the same period. This difference was then normalized by the standard deviation of the historical precipitation to establish the indices. The results are presented in Figure 6.8.

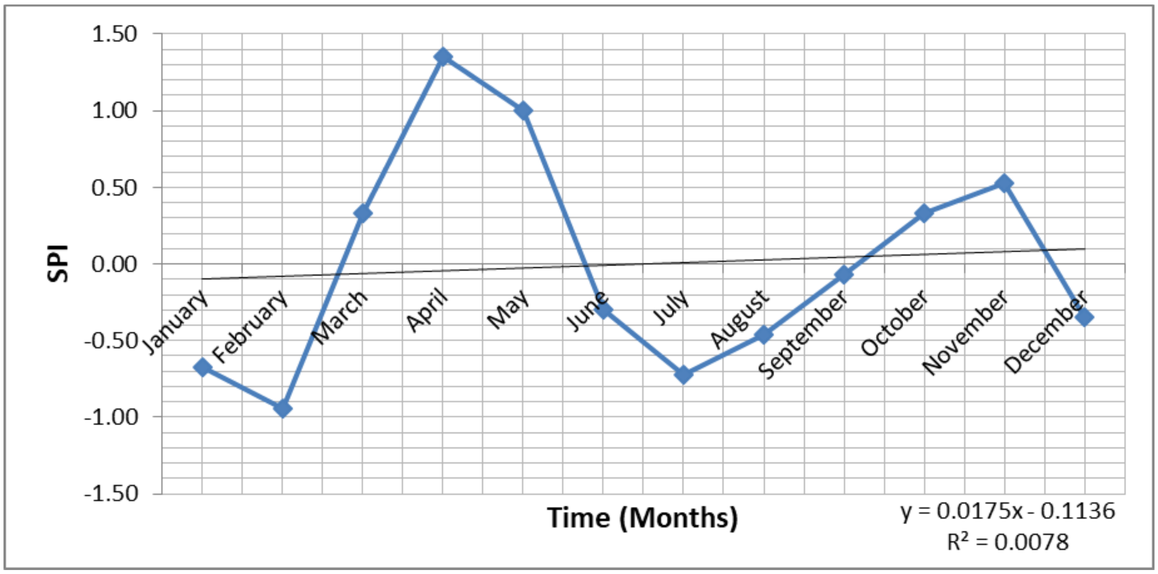

Figure 6.8: Drought index in Siaya County

Source: Field data (2023)

The analysis indicated that within 12 months' time period, seven (7) months SPI values were below the positive mark while five (5) month time periods were all within the positive values implying normal climate conditions. According to Mckeel *et al*. (1993) a drought event is defined when the SPI value reaches -1.0 or less and drought ends with the values reaching +1 value. The analysis therefore showed that within the time period

(1991 – 2021), 58% (7/12) of the months in every year experienced drought conditions while just 42% (5/12) had normal climatic conditions in Siaya County. In reference to Figure 6.8, these results agree with the periods of drought generally profiled in Siaya County climate change action plan 2023 – 2028 GoK (2023) where December, January and February (DJF), that is the first, second and twelfth month; June July and August (JJA) that is the sixth, seventh- and eighth-month indices are below the positive mark indicating drought. Regression analysis conducted display a weak positive $R^2 = 0.007$ relationship indicating low significance towards the increasing episodes of drought with regard to the trend line.

6.5.2 Drought duration in Siaya County

In reference to the results in Figure 6.8, in terms of duration of occurrence, the longest drought episodes occurred from June, July, August and September lasting for 4 months followed by December, January to February lasting for 3 months within the period of study in the study area. This was also supported by participants in the Focus group discussions with majority indicating DJF as the time when the droughts normally have an impact because of the longer time it takes;

> "As much as there occurs drought spells within a year, the one that starts in December upto early March normally has a great impact on our farms as compared to any other in the year such as in July or in August".

The participants disagreed on any other duration more that three months of persistence to drought. However, some participants seemed to have concensus that the prolonged drought persited within three months followed by intervals of short rainfall that occurred for days then the dry conditions resume.

6.5.3: Drought Intensity in Siaya County

In reference to Figure 6.8, drought severity analysis shows that the 12 months period displayed a mild drought. According to McKee *et al*., (1993) SPI values between above zero (0) is categorized as no drought, 0 to -0.99 is as mild drought, -1.00 to -1.49 as moderate, -1.5 to -1.99 as severe while -2.00 and less is categorized as extreme. Therefore, cumulatively the drought exhibited in the study area is attributed to the 7 months lying below zero (0) from the analysis that falling between 0 to -0.99.

According to Tanarhte *et al*., (2024), drought conditions can negatively affect agricultural production and mainly of food crops irespective of level of intensity. The study found out that the response about how intense the droughts have been was based on the level of negative impact due to drought episode caused on the agricultural systems like food crops in the study area. According to Mishra and Singh (2010) apart from other physical indicators such as stream flow and rainfall, drought severity can also be measured based on its negative impacts to other interdependent systems like agriculture and water availability and supply.

6.5.4: Frequency of drought in Siaya County

In reference to Figure 6.8, the results showed that in Siaya County, there occurred two drought episodes within a year and mainly in the December, January and February (DJF) and the June, July and August (JJA) seasons. It therefore means that drought occurred and recurred after every three (3) months in a year. These episodes occurred with an interval of three months of March, April and May of wet season then a nother drought episode of June, July and August after which another wet season of short rains of

September, October Novermber (SON) and the circle continued for the rest of the years under the period of study (1991 – 2021). The two episodes of droughts had months falling below 0 mark to the negatives such as DJF indexed at -0.4, -0.6 -0.9 respectively, intervaled by wet seasons of MAM then another drought season of JJA indexed -0.4, -0.8 and -0.50 respectively below the 0 mark.

These results agree with the views of focus group discussion participants that the drought occured every year and twice every growing seasons which are "*opon and chiri*" in a year in the study area. This was also in accordance with a key informant from the Department of meteorology, Siaya meteorological weather station's views that droughts occur at least ones a year in Siaya County. However, droughts differ both in temporal and spatial scales where Siaya County has varied geographical characteristics that make different parts of the County to experience drought at different times. Through Focus group discussions, the participants also agreed that there are instances where the droughts also come between the months of June, July and August then resume from in December, January and February making its twice a year.

From participant A 6;

> "Our crops and livestock are normally affected by droughts and mostly as an extended effect of the drought that normally occurs between the months of December, January and February thereby affecting the main growing season between March, April and May. However, there are times when drought also come in the middle of the year".

6.6: Seasonal climatic anomalies in Siaya County

Table 6.8 presents the four seasons MAM, JJA, SON and DJF yearly indices for the period (1992 – 2021). This formed the basis for the seasonal climatic analysis for the study area in this study.

Table 6.8: Seasonal Standardized precipitation indices (1992-2021) for Siaya County

SN	Year	MAM	JJA	SON	DJF
1	1992	0.39	0.58	0.06	-1.03
2	1993	0.33	0.72	-0.37	-0.67
3	1994	0.65	0.06	0.58	-1.29
4	1995	1.03	-0.22	0.37	-1.17
5	1996	1.51	-0.52	0.07	-1.06
6	1997	0.78	-0.27	0.02	-0.54
7	1998	0.33	-0.05	-0.21	-0.08
8	1999	1.06	-0.36	0.25	-0.95
9	2000	0.50	-0.67	0.87	-0.70
10	2001	1.17	-0.30	0.39	-1.26
11	2002	0.88	-0.91	0.23	-0.19
12	2003	1.35	-0.30	-0.43	-0.63
13	2004	0.93	-0.71	-0.05	-0.17
14	2005	1.42	-0.66	-0.28	-0.47
15	2006	0.68	-1.03	0.66	-0.32
16	2007	1.28	-0.75	-0.17	-0.35
17	2008	1.03	-0.71	0.64	-0.97
18	2009	1.00	-0.84	-0.26	0.10
19	2010	1.54	-1.04	-0.10	-0.40
20	2011	0.44	-0.38	1.01	-1.07
21	2012	0.50	-0.17	0.27	-0.60
22	2013	1.40	-0.76	-0.06	-0.57
23	2014	0.75	-0.48	0.70	-0.98
24	2015	0.44	-0.83	0.84	-0.45
25	2016	1.18	-0.67	0.24	-0.75
26	2017	0.94	-0.78	0.64	-0.81
27	2018	1.46	-0.88	0.02	-0.60
28	2019	-0.03	-0.37	0.99	-0.59
29	2020	0.88	-0.74	0.72	-0.85
30	2021	0.92	-0.89	0.25	-0.29

Source: Researcher (2023)

The study performed a Standadized Precipitation Index analysis on the seasons that characterize the year in the larger Lake Victoria basin. These Seasons were; a) December, January and February (DJF), b) March, April and May (MAM), c) June July and August (JJA) and d) September, October and November (SON).

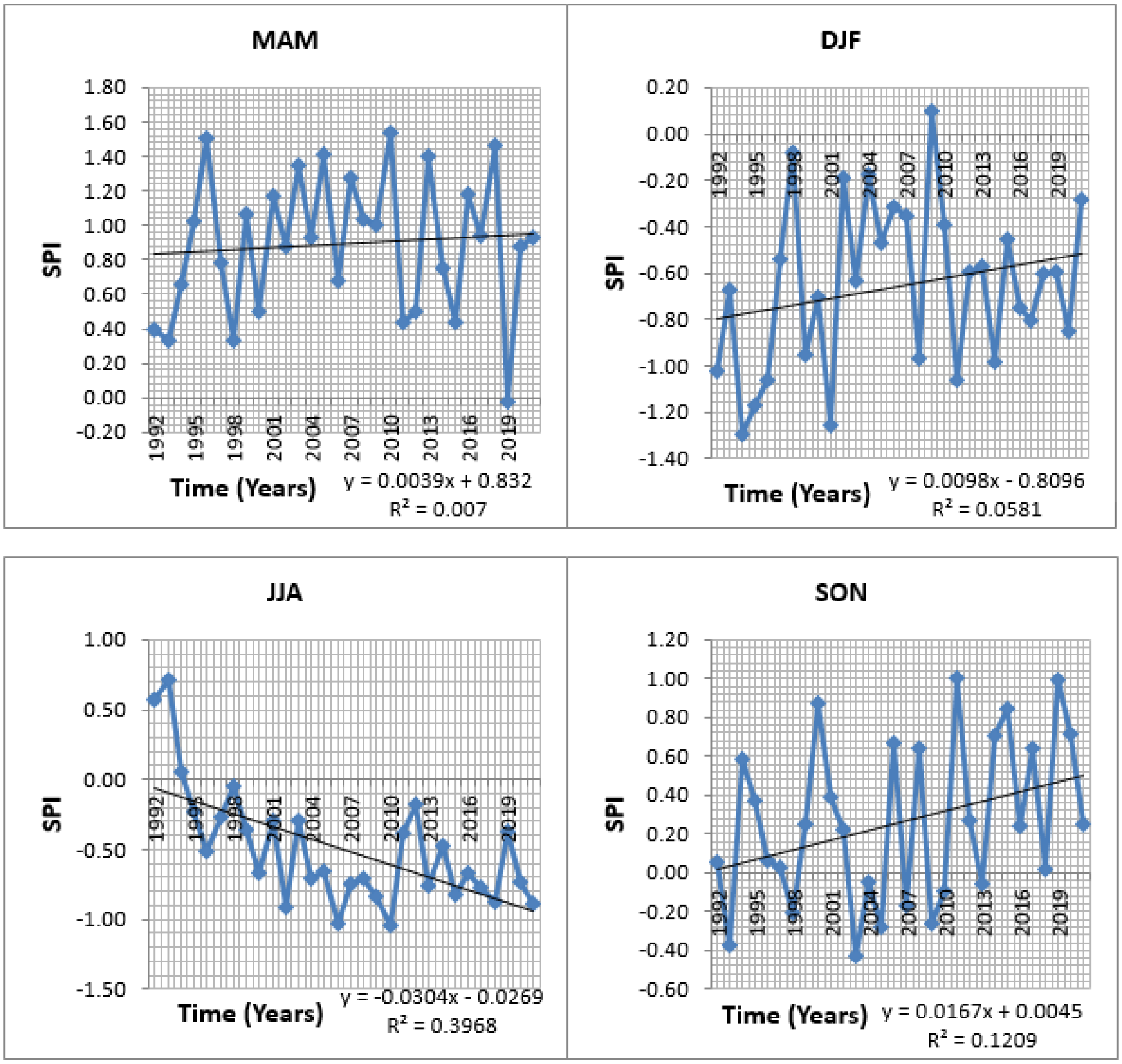

Figure 6.9: Seasonal climatic anormalies in Siaya County

Source: Field data (2023)

The study sought to test the climatic anomalies for each and every season that may inform the level of risk to the crops mainly in the growing seasons in Siaya County. The analysis in Figure 6.9 showed that MAM had relatively higher amount of annual rainfall compared to other seasons in the study area. The trend line also displayed an increasing trend in rainfall amount over the years under study (1992 – 2021) however of low significance with $R^2 = 0.007$. Results indicate none drought events within the MAM seasons over the period of study with all the years falling above 0 value on the SPI scale during MAM seasons . Results therefore show that just for one year (2019) MAM season experienced a mild drought condition in Siaya County. This means that 1/30 (3%) was on mild drought while the rest of the seasons experienced normal and extremely wet conditions in Siaya County.

Analysis for the season JJA show that annual rainfall received in that season under the period of study reduced as displayed by the trend lines. However, there occurs low significance with R^2 = 0.396 of the decrease in amount of annual rainfall. The analysis therefore shows an increase in drought episodes within the season of every year within the time period of study. Out of the 30 years, just 3 years (1991, 1992, and 1993) were above 0 SPI value indicating normal years; 27 years had JJA falling below 0 SPI value indicating drought where, 25 years exhihited mild drought while 2 year (2005 and 2009) JJA seasons exhibited a moderate drought falling between -1.00 and -1.49. The results showed that 3/30 (10%) of the seasons were on the normal, 25/30 (83%) were on the mild drought while 2/30 (7%) were on the moderate drought categories.

September, October and November (SON) season displayed an increasing annual rainfall amounts R^2 = 0.120 having low significance. The analysis shows that within the 30 year period, just 10 years had their SON falling below 0 SPI value that is 33.3% of the seasons experienced mild drought while 66.3% of the season experienced normal and wet climatic conditions.

The results further showed that there was an increasing amount of rainfall in the DJF season in the study area which, was exhibited by the increasing trend line. The analysis revealed that within the time period under study, just 1 year (2008) had its DJF season above the 0 SPI value depicting a normal climatic condition. It means that 29 years of the period under study were below 0, meaning they had drought episodes where 23 years experienced mild drought conditions in their DJF while 6 years experienced moderate drought conditions in their DJF seasons. It can therefore be duduced that 3% of the DJF season over the years were normal, 77% of the season experienced mild drought while 20% of the DJF seasons within the time period experienced moderate drought in Siaya County.

6.7. Trends in the individual dominant food crop yields in Siaya County

Based on the availability of the food crops data for the dominant food crops for the period (1992- 2021), the study used an eleven (11) year food crop production yield in metric tons for the dominant food crops in Siaya County (Appendix VI). This section analyzes and discusses trends of individual dominant food crop yields including: a) maize, b) sorghum, c) beans, d) cassava, d) sweetpotatoes and e) total annual crops production trends as presented in Figure 6.10. The analysis was done based on the annual individual crop yield data under the period (2012 – 2022) that were sourced from the Department of Agriculture, Irrigation and Livestock of Siaya County. The dominant food crops analysed were maize, sorghum, beans, sweet potatoes and cassava and the results are as presented in Figure 6.10.

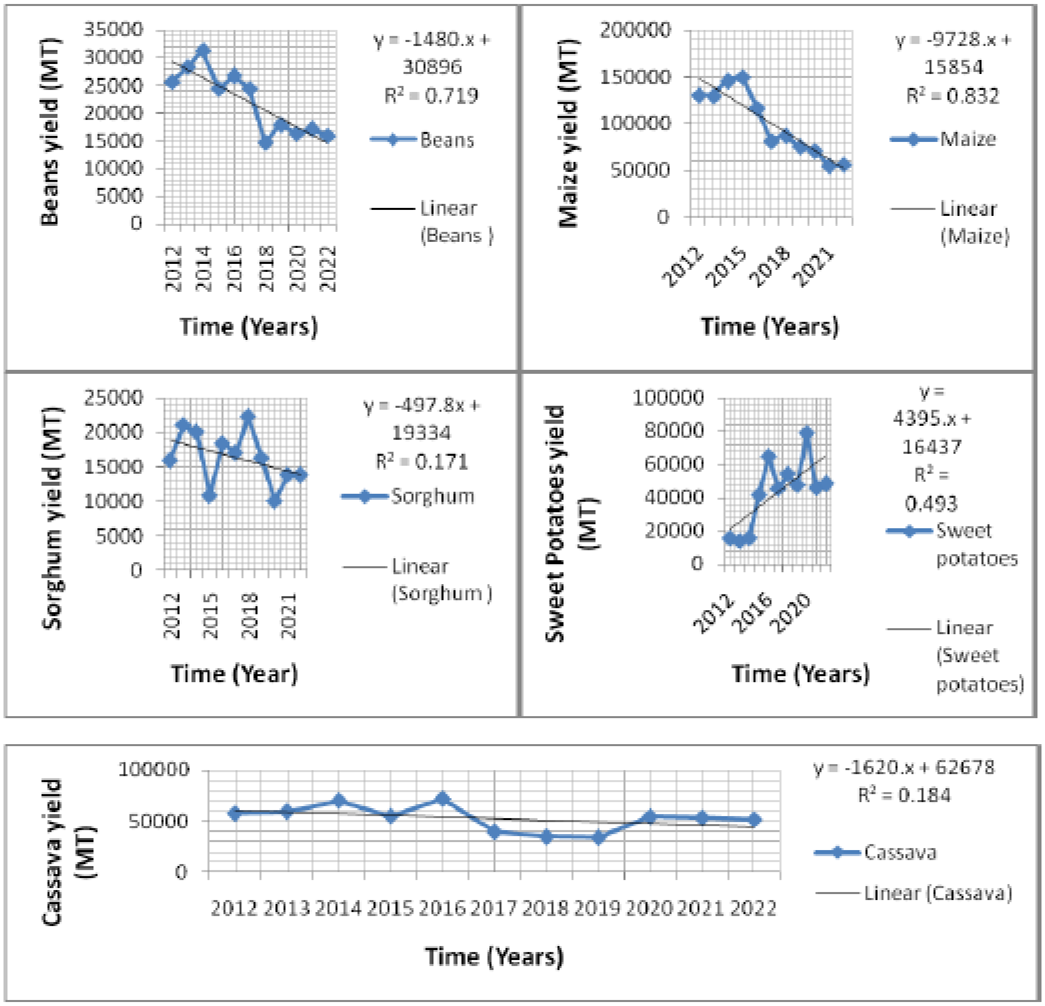

Figure 6.10: Annual individual dominant food crop trends in Siaya County

Source: Department of Agriculture, irrigation and Livestock of Siaya County (2023).

Table 6.10 presents data for the annual average food crop yields for the period (2012-2022) for all the dominant food crops as maize, beans, sorghum, sweet potatoes and cassava in metric tons.

Table 6.10: Average food crop production yield in Metric tons (Mt) in Siaya County

Year	Annual food crop yield Average (MT)
2012	37935.8
2013	38970.8
2014	42992.6
2015	45750.028
2016	45782.184
2017	34059.626
2018	36151.348
2019	31863.05
2020	35711.8
2021	26826.6
2022	27333.2
Food crop yield Average	36670.64
SD	6538.5497

Source: Department of Agriculture, irrigation, Livestock and Fisheries, Siaya County (2023)

The analyses illustrate that under the period (11 years), maize as the most dominant food crop had a mean of 100, 166.8 tons with a standard deviation of 35,375.19 tons. The analyses further reveal that there is a declining trend in annual maize yields in the study area with R^2 = 0.832, which reveals a significant decline in annual maize production with R^2 being much closer to the 1 threshold regression. This finding is supported by Odunga (2019), who observed that maize plays a critical role in addressing food security in Kenya, however, its production has been on the decline due to climate change, pests and diseases, erratic rainfall and droughts hence affecting food crop production.

Sorghum, had a mean of 16,346.46 tons with a standard deviation of 3,991.07 tons. The analysis shows that there was a decreasing trend in annual sorghum yields over the period under the study in the study area with R^2 = 0.171. Sorghum is an important food crop towards food security in the ASALs of Kenya due to its ability to tolerate various climatic risks (FAO, 2019). However, according to Bosire (2019) most farmers who are mainly small scale famers in the rural areas of Kenya have limited resources to sufficiently address the challenges that are not only based on the climatic conditions but of market dynamics therefore causing decline in the sorghum yield annually.

Beans as the most dominant leguminous food crop in the study area had a mean of 22,015.46 tons with a standard deviation 5,786. 53 tons. The analysis shows that there was a declining trend in beans annual yield over the period that was under study. The trend line analysis show an R^2 = 0.719 indicating a strong positive significance relating to R^2 nearing 1 threshold relationship. Beans farming greatly contributes to the Kenyan economy apart from being a staple food to majority in Kenya and other parts of the world (Chianu *et al*., 2008). The crop however has encountered a mirage of challenges thereby affecting its production hence contributing to food insecurity as a staple food. The challenges according to Kadenge *et al*. (2012) were attributed to low soil fertility, drought, pests and erratic rains in the crop growing seasons. These therefore have contributed to its declining trend in yield however it has an average yield of 1 tone per hectare in the whole country.

With regard to the tubers food crops in the study area, sweet potatoes had a mean of 42,807.45 tons with a standard deviation of 20, 756.22 tons. Annual sweet potatoes yields indicated an increasing trend over the period under investigation within the study area. The increase in production had a moderate positive significance with R^2 = 0.493. Lastly, Cassava as the other dominant food crop tuber in the study area displayed a mean of 52, 955. 73 tons with a standard deviation of 12,496.81 tons. Cassava production analysis indicated a declining trend in annual production for the period (2012 – 2022). However, the results displayed weaker significance but positive R^2 = 0.184 in relation to rate of decline in the study area.

The study further sought to establish the trend from the cumulative dominant food crop yields in Siaya county. This was to test the trend that exist regarding total food crop yield to ascertain whether the crop production was increasing or decreasing in Siaya county. The study therefore summed up the yields of all the crops per year for the period (2012 – 2022) then calculated the mean of the total yield per year. This was then used to plot in an excel for line graph and the trend is as shown in Figure 6.11.

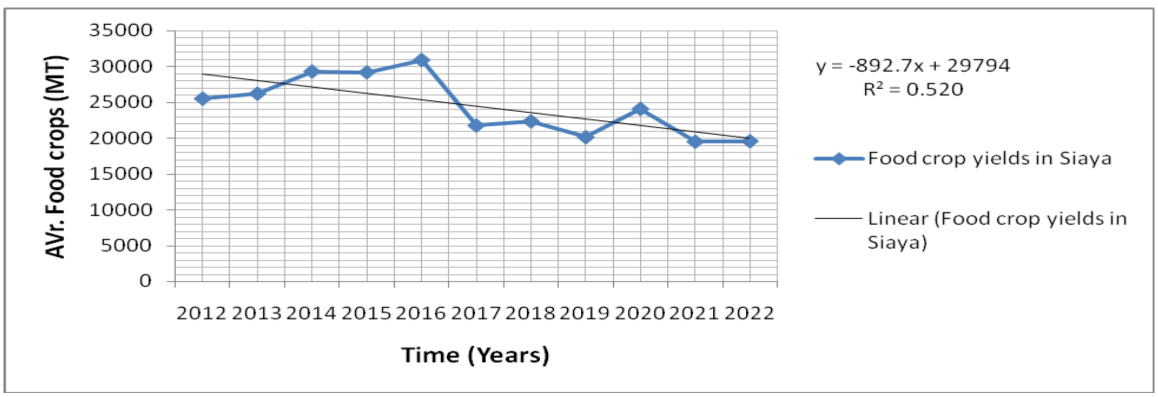

Figure 6.11: Annual mean food crops production in Siaya County

Source: Department of Agriculture, irrigation and Livestock of Siaya County (2023).

The study analyzed the yearly mean of the total dominant food crops in the study area under the period of study (2012 – 2022). The results in Figure 6.9 Show that the dominant food crops had a mean of 234,291.9 tons with a standard deviation of 41,034.06 tons. The analysis displays a generally declining trend in food crops production in the study area with R^2 = 0.520. The trend therefore reveal that the decline had a strong positive significance over the years (2012 – 2022) that may have affected food security in Siaya County.

6.8: Correlation between climate trends and the dominant crop yields for food security in Siaya County

The study conducted correlation test involving flood trends using the probability of exceedance and its relationship with the dominant crop yields; and drought episode trends and yields of the dominant crops of Maize, beans, sorghum, cassava and sweet potatoes focusing on the 2012 – 2022 period in Siaya County.

6.8.1 Correlation between flood trends and the dominant food crop yield in Siaya County

To analyze the relationship between climate trends and food crop production, correlation was used with null hypothesis (H_0) that there is no statistically significant relationship between climate trends and the dominant food crop yields in Siaya County. The results are as shown in Table 6.11.

Table 6.11: Summary of the relationship between crop yield and floods in Siaya County

SN	Crop type	Correlation coefficient	P – value
1	Maize	- 0.830	0.006
2	Sorghum	-0.319	0.403
3	Beans	-0.785	0.012
4	Sweet potatoes	-0.864	0.003
5	Cassava	-0.515	0.156
6	Yearly average crop yield	0.507	0.164

Source: Department of Agriculture, irrigation and livestock of Siaya County / Researcher (2023)

In testing the relationship between flood probability of exceedance and maize yields with regard to period under study (2012 – 2022), results show a correlation coefficient of -0.830 revealing a strong negative relationship between probability of flood exceedance trends and maize production. In this regard, the analysis shows that an increase in flood probability under the period (2012 – 2022) resulted on decrease in maize production. Additionally, significance 2 tailed analysis displays p value of 0.006 lower than 0.05 confidence level. This, therefore revealed that there is a statistical significantly correlation between flood trends and maize production in the study area. According to Lobell *et al*. (2011) there is a significant relationship between floods and maize production due to the fact that maize has cardinal ecological requirements for establishment, growth and development for yields. It means that increased trends of floods in growing seasons affect maize production. Adequate and well distributed precipitation is essential and any changes over the years from the required precipitation has the probability to reduce cumulative maize yield where any exceedance in rainfall can cause water logging and nutrient leaching hence reduced maize yield (Challinor *et al*., 2014).

Flood trends and sorghum had a coefficient correlation of -0.319 representing a negative relationship between flood trends and sorghum production. Where, the analysis shows that over the period, increased floods from any probability of exceedance reduced the sorghum production. The analysis also produced a 2 tailed significance of 0.403, $p > 0.05$ which translates to no statistically significant relationship between flood trends and sorghum production in the study area. Sufficient rainfall is a critical factor for the production of sorghum when it's sufficient and well distributed therefore, excessive rainfall that may cause water logging can negatively affect its yield. According to Hadebe *et al*. (2016) sorghum yield can be influenced by the variations in the climate trends influenced by temperature and rainfall changes over time in a given location and time. On the other hand, temperature plays a critical role in its production therefore sorghum as a warmer season crop, which requires higher temperatures during the growing season has the highest probability to increase yields (Baudron *et al*., 2014).

Beans and flood trends presented a coefficient correlation of -0.785 showing a strong negative relationship between the two variables. During the period under study, increased trends of flood reduced the beans crop production. Additionally, a 2 tailed significance level of 0.012, $p < 0.05$ was displayed from the analysis. It means that there was a statistically significant relationship between the flood trends and beans production. Climate change can have both positive and negative effects on crops such as beans where, increased frequencies and intensities in weather extremes such as flood exceedance rainfall can influence beans production (MoA, 2011).

Flood trends and sweet potatoes gave a correlation coefficient of -0.864 displaying a strong negative relationship between the two variables. The analysis revealed that increased probability of flood trends reduced production of sweet potatoes over the years. The relationship gave a p-value of 0.003 between the two variables of probability of exceedance of floods and sweet potatoes production which was statistically significant at p value < 0.05. According to Villordon *et al*. (2009), sweet potatoes are generally resilient crops and adapts to a range of climatic conditions to a given extent. However, extreme or prolonged exposure to extreme climatic conditions like floods can influence the yield cumulatively over a period of time. There is need to monitor climate trends and understand specific ecological requirements for potatoes production in a given location and mitigate any potential risks (Siegel, 2005).

Finally, a correlation between flood trends probability and cassava was conducted and a correlation coefficient of -0.515 was generated. This depicts a negative relationship between the two variables where, increased trends in floods probability reduced cassava production in the study area. Moreover, the analysis displayed a significance level of 0.156, p value > 0.05. This shows that there was no statistical significance in the relationship between flood trends probability and cassava production. Cassava is a tropical crop that is considered resilient to changing trends in climate. However, long term extreme changes have the probability to cause significant changes in yields (Sarka *et al.*, 2020).

The study further conducted a correlation analysis to establish the relationship between the flood trends probability and cumulative food crop production in Siaya County. The results show a correlation coefficient of 0.507 illustrating a positive relationship between the two variables. Also, a 2 tailed significance level of 0.164 was exhibited with p value > 0.05 hence presenting lack of statistical significance in the relationship between cumulative food crop production and flood trends probability in Siaya County.

6.8.2: Correlation between drought trends and the dominant food crop yield for food security in Siaya County

The study sought to establish the relationship between climate anomalies of drought occurrence and food production. Correlation was used with null hypothesis (H_0) that there is no statistically significant relationship between drought episodes and the dominant food crop yields in Siaya County. Results are as presented in Table 6.12.

Table 6.12: Summary of the relationship between Drought and crop yields in Siaya County

SN	Crop type	correlation coefficient	P -– value
1	Maize	-0.276	0.040
2	Sorghum	-0.468	0.172
3	Beans	0.207	0.567
4	Sweet potatoes	0.298	0.003
5	Cassava	0.485	0.155
6	Yearly average crop yield	-0.540	0.05

Source: Field data (2023)

Drought trend and annual Maize yield relationship was tested. The analysis showed that there exists a negative relationship where increase in drought episodes reduced maize production. The analysis generated a correlation coefficient of -0.276 signifying a negative weak relationship between drought trends and maize production. However, with a 0.040, $P < 0.05$ which was statistically significant resulting to reduced maize yield due to the existence of drought episodes in Siaya County. The results of this study are consistent to Liu *et al*. (2022) who established that the probability of maize yield failure increases with drought occurrences in China confirming that maize yields despite varying timescales have been negatively correlated with drought intensity in many parts of the world and mainly under moderate drought conditions.

Correlation between drought trends and Beans yielded a correlation coefficient of 0.207 indicating a positive though weak relationship where, existence of the drought episodes did not affect beans production to a larger extent indicating a no significance level of 0.567, $P > 0.05$. This reveals that the drought trend on the beans annual yield for the period under study was of no statistical significance. This finding resonates with GoK

(2014) on Siaya County risk profile where it is stated that drought has remained to be one of the greatest challenges to beans farming affecting it during its phenological stage mainly during germination and flowering.

Sorghum and drought trends level of association was tested and results showed that existence of drought episodes within the period under study reduced annual sorghum yields in the study area. Correlation analysis displayed a correlation coefficient of -0.468 indicating a negative though weak relationship between drought trends and sorghum production. The analysis also generated a 0.172, $p > 0.05$ level of significance suggesting low significance in the association of reduced sorghum yield to drought episodes in the study area. This finding could be based on the fact that sorghum is a drought tolerant crop and hence however much the results show a negative association, there is a null hypothesis on the impact of drought on the sorghum annual yields in the study area. Agreeably, GoK (2013) confirmed that sorghum is drought tolerant and is steadily replacing other staple food crops like maize in Siaya County

Sweet potatoes production in the study area exhibited a positive relationship with drought trends in Siaya County. Analysis displayed a 0.298 correlation coefficient indicating that existence of drought episodes within the time period under study did not reduce the annual yield of sweet potatoes. Analysis showed an association with significance 0.003, $p < 0.05$. It can be derived that sweet potatoes production had nearly no effect from the drought occurrences in Siaya County during the (1991 – 2021) period of study. It therefore showed that due to its nature of tolerance to droughts conditions, the annual crop yields were not affected negatively. Sapakhova *et al*., (2023) on sweet potatoes as a key crop for food security under the conditions of global climate change findings confirmed that sweet potatoe is an adaptable crop that produces large amount of food per unit area and time during dry and even short rainy periods giving it has an advantage over other crops and hence should be adopted by communities.

Cassava annual yields and drought trends in Siaya County posted a positive relationship with a correlation coefficient value of 0.485. The analysis showed that with the drought occurrence, cassava annual production trends were not affected but increased. Statistical analysis gave significance level of 0.155, $p > 0.05$ indicating a non-significant increase in cassava annual yields hence drought however impacted negatively on the cassava crop production in Siaya County. These results hence resonate with Muiruri *et al*., (2021) on mechanisms and approaches towards enhanced droughts tolerance in cassava which is a drought tolerant crop mainly used for human consumption however, increased drought and drought like conditions are projected to affect cassava productivity in future.

Lastly, the study sought to establish if there was a statistical relationship between drought trends and annual total food crop production in the study area. Analysis indicated that there was a negative strong relationship where occurrence of drought episodes in the period under study reduced cumulative annual food crops yields in Siaya County relating to a correlation coefficient of -0.540. Level of significance of 0.05, $p = 0.05$ indicating a close association that the drought occurrences influenced negatively the total annual food production reducing the yields of total food produced hence contributing to food insecurity in Siaya County. Globally, there has been a negative correlation indicating a decreasing trend of dominant food crop yields with the increasing trend of drought conditions (Hendrawan *et al*., 2023). This therefore shows that the continued increase in drought episodes will result to gradual decrease in food crop production hence increased low food crop production in many parts of the world including Siaya that has shown increase in temperatures and trends in drought episodes.

CHAPTER SEVEN

EFFECTIVENESS OF DISASTER RISK MANAGEMENT APPROACHES ON FOOD CROP PRODUCTION IN SIAYA COUNTY

7.1 Introduction

This chapter presents results and discusses findings of objective (iv) which was; to evaluate the effectiveness of the disaster risk management approaches on food crop production in Siaya County. This section is therefore divided into sub sections discussing findings on effectiveness of a) prospective disaster risk management approach, b) corrective disaster risk management approach, c) compensatory disaster risk management approach d) community – based disaster risk management approach, f) evaluation of the significant levels of each approach, g) general effectiveness and the last section h) evaluating the approaches influence to food crop production in Siaya County.

7.2 Effectiveness of the prospective disaster risk management approach on food crop production in Siaya County

The study sought to evaluate the effectiveness of the prospective disaster risk management approach on food crop production. Table 7.1 therefore presents results of the household response about the effectiveness of prospective disaster risk management approach activities such as a) Greenhouse gases reduction activities, b) Land use planning, c) agroforestry, and d) early warning information.

Table 7. 1: Effectiveness of the prospective disaster risk management approach on food crop production

	Risk management Activities	**Very effective** (%)	**Effective** (%)	**Less effective** (%)	**Not effective** (%)	**Don't know** (%)
1	**GHG reduction activities**	5	22	36	25	12
2	**Land use Planning**	12	21	40	22	5
3	**Agro-forestry**	2	11	51	29	7
4	**Early warning information**	25	49	18	7	1

Source: Field data (2023)

7.2.1 Effectiveness of GHG reduction activities towards food crop production in Siaya County

Table 7.1 shows that household respondents ranked effectiveness of greenhouse gases reduction activities as 5% (19) very effective, 22% (85) effective, 36% (139) less effective, 25% (96) not effective and 12% (46) not sure of its effectiveness towards enhancement of food crop production in the study area. The study sought to conduct further analysis using inferential statistics to establish the statistical relationship between the effectiveness of the greenhouse gas reduction activities and food crop production. The results from the inferential statistics analysis exhibited a Chi – square test ($\chi^2_{12,0.05}$ = 26.02) with p-value of 0.011 at ($P<0.05$). The analysis shows that there is a statistical insignificance of greenhouse gas reduction activities on food crop production in Siaya County.

Analysis therefore revealed that in Siaya County, Greenhouse Gas reduction activities are not effective in food crop production. This finding also resonates with the views of the focus group discussion participants where it was evident that the participants could not find a direct relationship between the greenhouse gas reduction activities and food crop production. However, they were in a position to point out at some of the energy saving technologies as applied by the households in the study area that they believed are helping to reduced greenhouse gases from the atmosphere.

From FGD participant C 6:

> "We have various initiatives and programs that have brought us energy saving technologies that we were taught that if we use them then, we shall be contributing to the greenhouse gas reduction hence healthier climate. Therefore, majority of the households in this community use energy saving cooking stoves from "Tembea", then others have also embraced use of solar energy for lighting purposes".

According to Fischer *et al*., (2005), climate change affects both the quality and quantity of land that is used for food crop production. It is therefore expected that a reduction of the GHGs should improve the quality and quantity of the agricultural land. However, there is a close link between agricultural systems such as production and transportation and the increase of the GHGs in the atmosphere. This hence reduces the efforts of the GHGs reduction activities for a favorable climatic condition. This therefore justifies to the respondent's views on the GHG reduction activities being not effective in improving the quality and quantity of the agricultural land that should be viable enough to enhance food crop production in Siaya County.

7.2.2 Effectiveness of land use planning towards enhancing food crop production in Siaya County

Table 7.1 show results of analyzed data revealed that 12% (46) indicated very effective 21% (81) effective, 40% (154) less effective, 22% (85) not effective and 5% (19) not sure of the effectiveness of land use planning by the household respondents in enhancing food crop production in Siaya county. Equally, the study conducted an inferential statistics analysis to establish the statistical relationship between land uses planning in enhancing food crop production in Siaya County. A Chi – square test ($\chi^2_{12,0.05}$ = 36.21) with p-value of 0.048 at ($P<0.05$). Analysis show that in Siaya County, land use planning is effective but of low significance with regard to food crop production enhancement.

Land use planning through zoning where agriculturally viable lands are protected and allocated to specifically agricultural purposes can be of benefit and could contribute immensely to food crop production. It is expected that while putting the land into its rightful usage optimizes productivity such as that of agriculture. This was found to be in tandem with the FGD participants views where they attested that in Siaya County like other places in Kenya and the whole world, other forms of development are on the rise hence reducing the agricultural land while reduction in agricultural land through urban and homestead constructions have continuously reduced household farmland sizes with the increase in population.

The study established that there are efforts through the Kenya land zoning policy to put agricultural lands in most sustainable and productive ways however, it was evident that implementation of the policy was the greatest challenge hence affecting the farm lands that are expected to be used for agricultural production. The challenges such as population growth and need for land to build homesteads, urbanization effect and generally failure to implement the land use policy to conserve and protect agriculturally viable lands hence are the main factors that have reduced its effectiveness towards enhancement of food crop production in Siaya County as identified by the participants for the study. According to Lemay (2009), issues of urbanization, population dynamics if effectively dealt with can reinforce the protection of the farmlands and farm activities and hence provide a better guarantee of improving food crop production and also contribute to food security sovereignty in many parts of the world.

7.2.3 Effectiveness of agro forestry towards food crop production in Siaya County

Table 7.1 results show that household respondents ranked agro-forestry as 2% (8) very effective, 11% (42) effective, 51% (196) less effective, 29% (112) not effective and 7% (27) not sure about the effectiveness of agro-forestry in enhancing food crop production in the study area. An inferential analysis was done to establish the level of significance of agro-forestry effectiveness towards food crop production in Siaya County. A Chi – square test ($\chi^2_{12,0.05}$ = 17.96) with p-value of 0.05 at (P = 0.05). The analysis therefore reveals that agro-forestry is less effective in enhancement of food crop production in Siaya County.

This is in relation to the household heads views where over 51% indicated that it contributes to food crop production but of low significance. According to (Ellison *et al*., 2017) however, there has been a historical debate on whether forests are users or contributors to rainfall in trying to justify the link between the forests and rainfall, forests play a critical role in regulating some extreme climate change like drought on rainfed crops. The study observed through the participants in the FGDs that at one point or the other households were involved in agro-forestry.

From a FGD participant C10:

> "We as the people in this community have participated in tree planting either on their farms or in various public spaces and we therefore believed that there would be increased rainfall amounts locally and within the study area hence contributing to the needed agricultural water for increased agricultural production".

According to key informants in the Ministry of environment and climate change, agro-forestry is expected not only to increase the vegetation percentage that would attract rainfall in an area but also to reduce soil erosion that may affect the agricultural lands.

> "For agriculture to be beneficial, there is need to ensure that its fertility is maintained and improved on where trees play a greater role in ensuring not only for enough rains but also improvement of soil fertility when the stands and cover is increased."

However, the study revealed that afforestation was slow in the study area and couldn't be compared to the rate at which deforestation was taking place in the study area hence reducing its effectiveness towards the agricultural production and food security enhancement. According GFW (2023) in 2023, Siaya County lost 253 ha of natural forest to 0.42% forest cover that is slightly below the national's 7.4%.

7.2.4: Effectiveness of early warning information towards food crop production in Siaya County

In reference to Table 7.1, results show that household respondents ranked early warning as 25% (96) very effective, 49% (177) effective, 18% (69) less effective, 7% (27) not effective and 1% (4) not sure about the effectiveness of early warning information in enhancing food crop production in the study area. The study sought to establish statistical relationship of early warning information effectiveness to food crop production in Siaya County. A Chi – square test ($\chi^2_{12,0.05}$ = 20.50) with p-value of 0.02 at ($P < 0.05$). The analysis therefore shows that early warning information effectiveness is statistically significant in enhancing food crop production in Siaya County.

In this study, early warning information entailed the usage of the information provided by the authorities such as the Kenya Meteorological Department through different media like "Barazas" and local media stations. The study established that the information that were provided were mainly about the impending climatic occurrences and risks in the study area. The study observed that the authorities supplied the information at the right time; however, there was lack of accuracy in the predictions of the possible hazards such as drought, floods and pest invasion to the crop lands.

Findings revealed that the existing dynamics in the atmosphere that has affected prediction and changes the atmospheric condition from time to time also led to unreliability of the warning information from the authorities by the community. However, the study found out that the households had adopted ways to supplement the warning information with the indigenous from the elderly members of the community in Siaya County. It was therefore evident that in Siaya County, households had integrated indigenous knowledge and the scientific knowledge in predicting the rains for agricultural activities for food production, prediction of climatic hazards like floods and drought that may affect food crops in the crop lands and livestock. This therefore could be the reason why the activity is considered to be effective compared to the rest under prospective approach of disaster risk management in Siaya County.

7.3 Effectiveness of corrective disaster risk management approach on food crop production in Siaya County

To evaluate the effectiveness of the corrective disaster risk management approach in improving food crop production, the study sought to test the various activities under this approach such as a) soil and water management strategies b) drought tolerant crops, c) Pest and disease management, d) Crop diversification, and e) Flood management strategies practiced by the household respondents in Siaya County as presented in Table 7.2.

Table 7. 2: Effectiveness of the corrective disaster risk management approach on food crop production

		Very effective (%)	**Effective** (%)	**Less effective** (%)	**Not effective** (%)	**Don't know** (%)
1	**Soil and water Mgt. Strategies**	18	51	13	12	6
2	**Drought tolerant crops and livestock**	20	63	11	6	0
3	**Pest and disease mgt.**	0	9	37	39	15

4	**Crop diversification**	48	37	10	4	1
5	**Improved storage facilities**	1	8	35	56	0
6	**Flood mgt. strategies**	4	11	69	16	0

Source: Field data (2023)

7.3.1 Effectiveness of soil and water management strategies towards food crop production in Siaya County

Soil and water management is effective in enhancing food crop production in Siaya County. This is as evidenced by the results in Table 7.2 that showed that 18% (69) of the household heads indicated that the strategies were very effective 51% (183) effective, 13% (50) less effective, 12% (46) not effective, while 6% (23) not sure about the effectiveness of soil and water management in enhancing food crop production in the study area. To test the level of significance of the effectiveness of soil and water management strategies towards food crop production, an inferential statistics analysis was conducted and A Chi – square test ($\chi^2_{12,0.05}$ = 9.48) with p-value of 0.004 at ($P < 0.05$) was displayed from the analysis. This result shows that there was a statistical significance of soil and water management in enhancing food crop production in Siaya County.

However, there is a population of the household who have not realized their effectiveness. From the participants in the focus group discussions, it was evident that effectiveness was measured in terms of change in the agricultural yields. There were some participants who had experienced change in terms of yield mostly in the dominant crops such as maize, beans, sorghum, and even the kales. Therefore, the participants attributed this positive improvement in yield to the adoption of the soil and water management techniques.

From FGD participant D 3:

> "Currently, at least households can expect something from their farms at the end of the season as compared to some times back. Were it not for the Kenya Climate Smart Agriculture Project activities, then most of us would still be experiencing lower harvest from our farms".

The study observed from the participants that households that harvested one bag of maize from one acre have realized a significant increase in the yield which is attributed to the soil and water conservation practices in the study area. However, there are households which haven't realized any significant change in their produce which explains the percentage of the households that indicated the ineffectiveness of the strategies. According to the key informant from the agricultural extension office in the study area, apart from the adoption of the best agricultural practices among farmers there exists insufficiency or lack of sustained usage of the technology among farmers that may reduce the effectiveness of the strategies.

The implementation of the soil and water management techniques has the ability to improve crop production. According to Oduor (2021), soil and water management through mulching, minimum soil tillage, on farm water management such as harvesting through ponds and irrigation, significantly increase water productivity and soil fertility. The improvement in the soil health therefore has a ripple positive effect on the crop yield and even pasture quality hence increased food security.

7.3.2 Effectiveness of the drought tolerant crops to food security in Siaya County

Table 7.2 shows that household respondents ranked drought tolerant crops practice as 20% (77) very effective, 63% (243) effective, 11% (42) less effective, 6% (23) not effective, and 0% not sure of the effectiveness of the practice of drought tolerant food crops such as sorghum, millet and cassava in enhancing food crop production in the wake of climate change. To establish the level of significance of effectiveness of practicing drought tolerant crops to food crop production, an inferential statistical analysis was conducted. The results show a Chi – square test ($\chi^2_{9,0.05}$ = 9.91) with p-value of 0.049 at ($P < 0.05$). The analysis therefore shows that the practice of drought tolerant crop is effective though of low significance to food crop production enhancement in Siaya County.

According to FAO (2019), there are numerous benefits of growing drought tolerant crops which includes producing large crop yields. This sentiment is also echoed by Karthika and Govintharaj (2022) that growing climate resilient crops such as maize and sorghum varieties in most environments lead to 25% additional yield. This is attributed to the fact that these crops are still able to grow and develop in periods of prolonged dry spells. However, the study established from the Key informant from the ministry of agriculture that there was need for concerted efforts by the farmers to integrate the drought tolerant crop growing with the soil and water management practices for the long-term effectiveness to be realized.

7.3.3: Effectiveness of pest and disease management to food crop production in Siaya County

Results in Table 7.2 show that household respondents ranked pest and diseases as 0% under very effective, 9% (35) effective, 37% (143) less effective, 39% (150) not effective, and 15% (58) not sure of the effectiveness of the pest and diseases in enhancing food crop production under the changing climate. An inferential statistics analysis was conducted to test level of significance and a Chi – square test ($\chi^2_{9,0.05}$ = 2.45) with p-value of 0.09 at (P > 0.05) results was generated indicating that there is no statistical significance on the effectiveness of pest and disease management practice to food crop production in Siaya County

The study established from the respondents that majority had very little knowledge or access to the pest and disease management information and resources. While the study assumed that from the ministry of Agriculture, Livestock and Fisheries the extension officers provide information on the best practices on pest and diseases management, majority of the participants had very little information on the best and advanced practices in managing the pests and diseases. It was also established from farmers that some still practiced the indigenous methods which were mainly of pest management such as use of ash and cow dung on crops in the field and those harvested.

According to Savary *et al*., (2019), global yield losses of important staple crops range up to 30% due to the kind of threats pest and diseases subject the crop lands to hence affecting the availability and safety of the food crop among populations. Employment of various pest and disease control measures such as using chemical sprays reduces pests and hence improves the health of the crops significantly (FAO, 2020). However, the study observed that some of the households avoided use of other forms of pests and disease control measures like pesticides in fear of their effects on the environment and specifically human beings. Measures to prevent or treat diseases may have negative effect on the farmers and also it has the capacity to make the pests and diseases causing agents more resistant to treatment. This therefore encourages the use of the indigenous methods by the majority which might not be so effective in protecting the crops.

However, according to a key informant from the ministry of agriculture, technology has ensured development of other measures apart from the usage of chemicals such as the technological advancement in genetic modification and development of a variety of crops which are pathogen resistant.

From the Key informant:

> "There is need to employ a variety of interventions and integrate with the early warning of climate variations that may facilitate spread of pests and diseases".

7.3.4 Effectiveness of crop diversification in enhancement of food crop production in Siaya County

Results in Table 7.2 shows that 48% (185) of the household respondents ranked crop diversification as very effective, 37% (143) effective, 10% (39) less effective, 4% (15) not effective and 1% (39) not sure about the effectiveness crop diversification in enhancing food crop production in the study area. The study further conducted an inferential statistics analysis to test the significance of effectiveness of crop diversification on food crop production. The results indicating a Chi – square of ($\chi^2_{12,0.05}$ = 6.29) with p-value of 0.03 at ($P < 0.05$) showed that there is a statistical significance of the effectiveness crop diversification towards food crop production in Siaya county.

Adoption of crop diversification minimizes risk exposure and safeguard food crop production (Twumasi and Asale, 2022). However, Makate *et al*., (2016) believe that integration of crop diversification with other factors such as access to extension services and use of fertility management practices significantly increase food crop production experiences in households. Resonating with this study's findings, WFP (2021) revealed that about 88% of the rural households cultivate multiple crops such maize, millet, yam and beans to survive the climatic risks.

Crop diversification has been identified as one of the most viable options in tackling food insecurity Jone *et al*. (2014), indicating a positive relationship between crop diversification and household food security and nutrition. Similarly, Herforth (2010) also posited a positive association between the number of crops grown and farm household food crop production in Kenya and Tanzania. However, Sibhatu and Qaim (2018) founded that there is little evidence to substantiate the assertion that increasing the number of crops is highly effective in satisfying sufficiency and availability of the food crops.

7.3.5: Effectiveness of storage facilities towards food crop production in Siaya County

In reference to Table 7.2, results show that household respondents ranked usage of storage facilities as 1% (39) very effective, 8% (31) effective, 35% (135) less effective, 56% (216) not effective, and 0% not sure of the effectiveness of storage facilities in enhancing food crop production in the study area. Additionally, an inferential analysis was conducted to test the level of significance of the effectiveness of storage facilities towards food crop production. Results, of a Chi – square test ($\chi^{2}_{9,0.05}$ = 3.9.10) with p-value of 0.07 at (P > 0.05). Analysis therefore showed that there is no statistical significance of the effectiveness of the storage facilities hence the practice being not effective in enhancing food crop production in Siaya County.

According to FAO (2018), addressing recurrent food insecurity needs not only increased food crop production but also an intervention in reducing post-harvest losses during storage. In a study on improved on – farm storage and seasonal food insecurity Brander *et al*. (2020) the findings revealed that improved storage facilities reduced the proportion of severely food insecure households by 38% on average on a lean season and up to 20% in the full season cycle in East African Countries such as Tanzania. However, the contribution of the storage to reduction of the harvest losses were highly attributed to simple and inexpensive technologies in storage such as use of hermetic bags. Hermetic bags limit- atmospheric oxygen that may cause desiccation of insects and other pests that may destroy stored grains (Murdock *et al*., 2012)

With reference to this study, the findings revealed that most of the households used traditional cribs, polythene sucks, baskets, pots, and drums in storage of their harvests while these are all prone to invasion by pests and rodents making the harvest vulnerable hence being viewed as ineffective. Additionally, it was also established that the other improved storage facilities that were available were government controlled and could only allow a certain amount that majority of the households couldn’t attain to be allowed to store their produce.

7.3.6: Effectiveness of flood management strategies towards food crop production in Siaya County

Results in Table 7.2 show that household respondents ranked flood management strategies as 4% (15) very effective, 11% (42) effective, 69% (266) less effective, 16% (62) not effective and 0% not sure of the effectiveness of flood management strategies in enhancing food crop production in the study area. An inferential analysis to test the statistical significance of flood management strategies towards food production, a Chi – square test ($\chi^2_{9,0.05}$ = 8.98) with p-value of 0.15 at ($P > 0.05$) indicated that there was no statistical significance of the effectiveness of the flood management strategies to food crop production in the study area.

The study established that among the strategies for flood management were increasing vegetation cover, adhering to building code of the storage facilities and employing flood control systems such as improving drainage systems. However, the study revealed that the measures had very minimal effect on reducing the impact of floods on the agricultural production. It was observed that majority of the participants could mostly relate the drainage systems and adherence to building code of the storage facilities as measures that can reduce the impact of the floods on the food crop production systems. In this regard and given the few who use the storage facilities adhering to the building code, most participants weren’t in a position to relate their effect.

However, according to FAO (2018), flood management strategies can have a significant impact on food crop production as floods have the potential to destroy the crops, destroy infrastructure and markets which in turn may affect food availability. According to a key informant from the ministry of water and natural resource management, effectiveness of these strategies mainly depends on their implementation and coordination with other policies and programs related to food crop production and disaster risk reduction which was low or non-existence in other parts of Siaya County.

7.4 Effectiveness of compensatory disaster risk management approach on food crop production in Siaya County

This study sought to evaluate the effectiveness of disaster risk management approaches on food crop production in Siaya County. In this regard the study evaluated the effectiveness of the compensatory disaster risk management approach as one of the disaster risk management approaches on food crop production. The study further sought to test the various activities under the approach such as a) contingency funds, b) food crop insurance, c) safety nets, and d) agricultural subsidies effectiveness in enhancing food security in Siaya County as presented in Table 7.3

Table 7. 3: Effectiveness of the compensatory disaster risk management approach on food crop production

	Risk management Activities	**Very effective** (%)	**Effective** (%)	**Less effective** (%)	**Not effective** (%)	**Don't know** (%)
1	**Govt. sourced Contingency Fund**	2	3	10	66	19
2	**Crop and Livestock insurance**	10	23	55	8	4
3	**Safety nets**	5	16	19	60	0
4	**Agricultural subsidies**	15	41	30	6	8

Source: Field data (2023)

7.4.1: Effectiveness of Government sourced contingency funds in enhancement of food crop production in Siaya County

In reference to Table 7.3, household respondents ranked contingency funds availability as 2% (8) very effective, 3% (12) effective, 10% (39) less effective, 66% (254) not effective, and 19% not aware of its effectiveness in enhancing food crop availability in the study area. An inferential analysis to test significance level of the contingency funds towards food crop production was conducted. The results exhibited a Chi – square, ($\chi^2_{12,0.05}$ = 6.55) with p-value of 0.30 at (P >0.05). The analysis therefore shows that there is a non-statistical significance in the effectiveness of the contingency fund towards enhancement of food crop production in Siaya County.

The study established that there was little knowledge about the existence of the funds mostly by the County government. However, the study observed that there were other activities from other non-Governmental organizations that were related to the functions of the contingency funds from Kenya Red Cross for those who had totally lost crops and livestock. These funds had mainly been used to facilitate coordination between different organizations involved in the emergency response towards food security challenges after a disaster.

Findings revealed that the ineffectiveness of the contingency funds originate from the inability of the county government to allocate funds or if they allocate then lack of priority leads to the funding being directed to other activities. It therefore means that when the funds were diverted then in case the agricultural production is affected by the extreme climatic conditions then the farmers are much more vulnerable where they aren't in a position to make an immediate recovery or to salvage the crops affected hence an effect on the food crop production. However, he confirmed that contingency funding has the potential of providing a quick response to food security emergencies through timely delivery of food and related resources during disasters such as floods and droughts.

According to IFAD (2021), effectiveness of contingency funds towards food crop depends on a range of factors such as the size of fund allocated, its speed of mobilization, and how well its targeted to address specific needs of the affected population by the disasters in a given location and time. This view also resonates with FAO (2019) which established that contingency funds can be an effective tool in addressing low food crop production situations. It was noted that this can only be effective if it's not viewed as short term measure but considered as a complement to building a more resilient food crop production system against the extreme climatic conditions such as floods and droughts.

7.4.2: Effectiveness of food crop insurance towards food crop production in Siaya County

Table 7.3 shows results of the household respondents that ranked food crop insurance as 10% (39) very effective, 23% (89) effective, 55% (212) less effective, 8% (31) not effective, and 4% (15) not aware of the effectiveness of food crop insurance in the study area. Further, an inferential analysis was conducted to test the level of significance of food crop insurance towards food crop production and results indicated a Chi – square result ($\chi^2_{12,0.05}$ = 13.91) with p-value of 0.047 at ($P < 0.05$). The analysis therefore shows that there is a weak statistical association hence the ineffectiveness of food crop insurance to floods, drought, pests and diseases that can help improve food crop production in Siaya county.

The study established that food crop insurance had become less effective at the county levels due to poverty where when a farmer is expected to subscribe to the policy terms, most of the policies are expensive therefore only cover a few of those who have the resources there by reducing the food security index. Secondly, the ineffectiveness was also observed to be due to failure of insuring companies to leave out coverage of certain risks such as of climatic nature. However, the study found out that that crop insurance can be more effective towards enhancing food crop production if the challenges and any existing limitations are taken into considerations while the policies are tailor designed to the benefits of farmers in a given location and time.

These views are also observed by (World Bank, 2017) that the insurance effectiveness can be realized in achieving food increased food crop production against risks and particularly in areas where agriculture is vulnerable to climatic hazards like floods, drought, pests, diseases and market fluctuations. Another study Miranda and Glauber, (1997) indicated that to realize effectiveness of crop insurance mostly and among the rural small-scale farmers, then knowledge about its benefits and access need to be a priority of organizations to adopt practices that reduce the likelihood of crop failure in the wake of climate change.

7.4.3: Effectiveness of safety nets in production food crops in Siaya County

Results in Table 7.3 show that household respondents ranked safety nets as 5% (19) very effective, 16% (62) effective, 19% (73) less effective, 60% (231) not effective, and 8% (31) not aware of the effectiveness of safety nets in production food crops and availability in the study area. To test level of significance, Chi – square test ($\chi^2_{9,0.05}$ = 8.95) with p-value of 0.12 at (P > 0.05) was generated. Therefore, the analysis shows that there was a non-statistical significance of safety nets availability making it ineffective in production of food crop in Siaya County.

The study further established that there were a variety of safety net strategies that are in place within the study area such as supplementary school feeding programs, elderly cash transfer program, work for food programs as the dominant programs as were identified by the study participants. However, most respondents did not consider them to be contributing to their household food due to their inefficiency contributed by other factors such as corruption and high level of bureaucracies to access the safety net programs. This is supported by Hoddinott (2014) that safety nets can be effective in addressing food insecurity and ensure sustainability but only if the underlying structural problems are prioritized on for sustainable solutions by policy makers and the relevant authorities.

According to Baret and Maxwell (2016) the effectiveness of safety net programs towards food security varies depending on several factors such as the targeted population, program type, and context of implementation. However, studies have shown that safety net programs can improve food security, particularly when combined with other interventions. Additionally, a study on food assistance programs found that such programs, when combined with nutrition education and other complementary interventions, can improve dietary diversity and reduce hunger (Skau *et al*., 2015). Similarly, Winder – Rhodes *et al.*, (2016) on cash transfer programs found that they can enhance food security and dietary diversity, particularly among vulnerable populations such as households with children or those living in poverty.

7.4.4: Effectiveness of agricultural subsidies towards food crop production in Siaya County

Table 7.3 show results of household respondents ranking agricultural subsidies as 15% (58) very effective, 41% (158) effective, 30% (116) less effective, 6% (23) not effective, and 8% (31) not being aware of the effectiveness of the agricultural subsidies in enhancing food crop production in the study area. In relation to level of significance, a Chi – square test ($\chi^2_{12,0.05}$ = 10.26) was conducted with p-value of 0.048 at ($P < 0.05$). Analysis therefore shows that there is low statistical significance on effectiveness of the agricultural subsidies towards food crop production in Siaya County.

The study established that the agricultural subsidies in Siaya County that helped increase yields were the climate smart seeds, affordable fertilizers and machinery like the tractors. However, some were not in a position to afford these tractors hence making them carry out various agricultural activities late against the seasonality therefore affecting their food crop production. Additionally, some of the challenges as identified to have affected the effectiveness of agricultural subsidies were socio – economic factors like poverty and negative attitude of some farmers against new technologies of farming.

Previous studies FAO (2021); Rada, (2017) show that agricultural subsidies can be effective in improving food crop production, which is crucial for meeting the growing demand for food worldwide. Subsidies can provide support to farmers who face financial challenges due to fluctuating prices or natural disasters, which encourages them to continue farming and maintain food crop production. Moreover, subsidies can be targeted towards specific regions or crops that are critical to food security, ensuring that they are produced in sufficient quantities. However, according to Thow and Gleeson, (2019), overproduction promoted by subsidies can also result in environmental issues, such as soil degradation, water pollution, and greenhouse gas emissions.

7.5: Effectiveness of community – based disaster risk management approach on food crop production in Siaya County

The study sought to evaluate the effectiveness of disaster risk management approaches on food crop production in Siaya County. In this regard, this study evaluated the community – based disaster risk management approach using various activities as a) prediction of hazards, b) planning of the risk reduction activities, c) implementation of the risk reduction activities, d) monitoring of the implementation of the risk reduction activities and e) risk analysis that the communities participate in towards enhancing food security in the study area as presented in Table 7.4.

Table 7. 4: Effectiveness of the community - based disaster risk management approach on food crop production

	Risk management Activities	Very effective (%)	Effective (%)	Less effective (%)	Not effective (%)	Don't know (%)
1	**Prediction of the hazards**	15	21	60	4	0
2	**Planning risk reduction activities**	1	7	20	50	22

3	**Implementation of risk reduction activities**	3	5	52	40	0
4	**Monitoring of implementation of risk reduction activities**	2	25	58	13	2
5	**Risk analysis**	0	1	17	36	46

Source: **Field data (2023)**

7.5.1: Effectiveness of prediction of the hazards towards food crop production in Siaya County

Results in Table 7.4 show that household respondents ranked prediction of climate related hazards as 15% (58) very effective, 21% (81) effective, 60% (231) less effective, 4% (15) not effective, and 0% not aware of its effectiveness in enhancing food crop production in the study area. Additionally, an inferential statistics analysis to test the significance level of the effectiveness was conducted. A Chi – square ($\chi^2_{9,0.05} = 12.96$) with p-value of 0.01 at ($P < 0.05$). Analysis therefore shows that there is a statistical significance of the effectiveness of prediction towards enhancement of food crop production in Siaya County.

The study observed that the community is involved in prediction of the hazards where the indigenous prediction was still considered and preferred by a large number of populations within Siaya County. However, it was underscored that when information of the climatic occurrences are relayed in relation to agricultural activities, the authorities or media seems to give less attention to the indigenous participation in prediction but report are usually based on the scientific prediction by the meteorological departments. This was then found out to have confusion to the households on which prediction is accurate hence leading to bad timing in agricultural activities that lead to low crop production making the participants terming it less effective.

According to Arora (2011), community involvement in predicting hazards can be an effective strategy for improving food crop production by allowing early identification of potential threats to their food production enables them to better prepare and take action to safeguard their food crop production systems. Similarly, FAO (2015) believes that efficient community participation in hazard prediction requires establishing effective communication channels between community members and local authorities responsible for monitoring and responding to hazards. Additionally, Cinner *et al*. (2012) in order to realize effectiveness of this approach community-based monitoring systems need to be set up for weather patterns, pests, and other hazards that could impact negatively food crop production.

7.5.2: Effectiveness of planning for risk reduction activities to food crop production in Siaya County

In reference to Table 7.4, results show that household respondents ranked their participation in planning of risk reduction activities as 1% (39) very effective, 7% (27) effective, 20% (77) less effective, 50% (193) not effective, and 22% (85) not aware with regard to the effectiveness of planning of risk reduction activities towards food crop production. A chi- square test for level of significance displayed results as ($\chi^2_{12,0.05}$ = 6.65) with p-value of 0.05 at (P = 0.05). This indicate that there is a statistically though of low significance on the effectiveness of community participation in planning for risk reduction activities towards food crop production in Siaya county.

There seemed to be an agreement with the key informant's views on the low effectiveness of the community participation in planning of the risk reduction activities in the study area by the respondents. According to the key informant, member of the disaster management committee:

> "Members of the community have not sufficiently been involved therefore reducing the strategy in planning for risk reduction activities hence low realization of the strategies effectiveness towards risk reduction in agriculture, however that there are factors that at times make the committee not to involve the community in planning as many times the community members have not shown interest while others have lacked needed understanding of planning. Additionally, there occurs high expectations by the community members whenever there are attempts in involving them in planning while many organizations do not allocate funds for such processes".

Community involvement in planning can be an effective approach towards community development such as on issues of household's food security through food crop production. However, Voigt –Graf, *et al.* (2014) believe that this may only be effective if planning is tailored to address specific needs of the community thus reducing risk to food crop production in the households in the wake of climate change. Studies (Pandey and Pal, 2015; FAO, 2018) have also shown that community members who are highly involved in planning of the risk reduction activities are more likely to support the agreed strategies and hence increasing the likelihood of the strategies being adopted and sustained for the benefit of the community.

7.5.3: Effectiveness of implementation of risk reduction activities towards food crop production in Siaya County.

Table 7.4 presents analyzed data from household respondents that ranked their participation in implementation of risk reduction activities as 3% (12) very effective, 5% (19) effective, 40% (154) less effective, 52% (200) not effective, and 0% not aware with regard to enhancement of food crop production An inferential statistics analysis to test the level of significance gave a Chi – square test result ($\chi^2_{12,0.05}$ = 11.64) with p-value of 0.001 at ($P < 0.05$) showing that there is a statistical significance to justify the less effectiveness of the participation of the households in the implementation of the risk reduction activities towards food crop production in Siaya county.

Additionally, this study established that majority of the households through the programs of Kenya Climate Smart Agriculture had been involved in the implementation of the risk reduction activities with the goal of achieving increased food crop production. However, the study established that socio –economic factors such as poverty is a contributing factor to low participation hence reducing the level effectiveness of community participation in the implementation of risk reduction activities.

Active community participation in the implementation of the risk reduction activities towards achievement of increased food crop production such as in crop diversification and in drought tolerant crops and livestock can be very effective in reducing the risks that mostly originate from environmental changes and climate change related (FAO, 2013). Consistent to this, Devereux (2002) believes that for the active engagement of the communities in implementation of the risk reduction activities and food crop production to be realized, there is need for risk activities to be implemented in the local context of the community without which they become ineffective.

7.5.4: Effectiveness of the monitoring of the implementation of the risk reduction activities for food crop production in Siaya County

Table 6.4 shows that household respondents ranked monitoring of implementation of the risk reduction activities as 2% (8) very effective, 25% (96) effective, 58% (223) less effective, 13% (50) not effective, and 2% (8) not aware of the effectiveness of the activity towards increased food crop production. Additional inferential statistics analysis to test the level of significance was done. A Chi – square ($\chi^2_{12,0.05}$ = 20.15) with p-value of 0.05 at (P=0.05) indicating a statistical significance though of low effectiveness of community participation in monitoring with regard to food crop production in Siaya County.

The study established that community participation in monitoring of the implementation of the risk reduction activities can be highly effective in achieving increased food crop production. However, a key informant from the County Disaster Management Committee, there were issues of concern such as lack of inclusivity based on the convectional knowledge and better understanding of the monitoring.

> “There should be an effective link between the community members and other stakeholders to improve monitoring towards achievement of food security through risk reduction activities implementation in Siaya County without which very little improvement will be realized”.

According to Gillespie *et al*., (2012) monitoring can be ineffective or yield low effectiveness mainly when the participants have very little or no knowledge and skills towards monitoring and evaluation of the implementation of the risk reduction activities. Additionally, FAO (2018) averred that the viability of monitoring the implementation of risk reduction activities towards achievement of increased food crop production can be when there exists a coherent partnership between the community members and other partners. Further, effective partnership in monitoring may also improve corporation and collaboration which are very critical for the success in the implementation of the risk reduction activities and hence achievement of improved food crop production (Singh, 2019).

7.5.5: Effectiveness of risk analysis towards food crop production in Siaya County.

Table 7.4 show results of household heads responses with regard to the effectiveness of risk analysis that was ranked as 0% very effective, 1% (39) effective, 17% (67) less effective, 36% (142) not effective, and 46% (177) being not aware of the effectiveness of the community participation in the activity towards improved food crop production in Siaya County. An inferential statistics analysis to test statistical significance resulted to a Chi – square ($\chi^2_{12,0.05}$ = 18.96) with p-value of 0.12 at ($P > 0.05$). Analysis hence shows that there is no statistical significance on the effectiveness of community participation in risk analysis towards food crop production of Siaya County.

The study established that majority of the households in the community perceived risk analysis as a preserve of the elites in the authorities and other organizations hence affecting their participation while the rest were not aware about their responsibility to participate in risk analysis. According to a key informant, a member of the County disaster management committee, the involvement of the community in risk analysis are effective because they have enabled the household heads to be in a position to identify the risk, vulnerabilities through surveys, participatory mapping and group meetings organized by the committee. However, the informant pointed out at the capacities to implement the necessary strategies to avoid, reduce and transfer risk that may affect them towards achievement of improved food crop production in Siaya County.

Community participation in risk analysis has helped in identify potential hazards also provided information related to floods and drought that can negatively impact food crop production. According to IFRC (2014), this information can inform the development of effective risk reduction strategies tailored to the community's resilience building against the risk identified and reduce vulnerability in the agricultural systems. Community participation plays a vital role in disaster risk analysis to achieve improved food crop production when the community is involved in the process it leads to a more accurate assessment of risks and vulnerabilities, and more effective planning and mitigation measures tailored to the community's specific needs (UNDRR, 2019).

7.6: Effectiveness of the Disaster risk management approaches (DRMA) on food crop production in Siaya County

The study conducted correlations between disaster risk management and food crop production in Siaya County. First correlations were conducted between individual approaches and food crop production and lastly between cumulative approaches and food crop production.

7.6.1 Individual disaster risk management approaches effectiveness towards food crop production in Siaya County

The study sought to conduct a statistical analysis on the effectiveness of the disaster risk management approaches towards improved food crop production. These analyses were conducted for individual approaches on their effectiveness towards enhancing food crop production and the results are as shown in Table 7.5.

Table 7. 5: Effectiveness of the individual DRMA towards Food crop production in Siaya County

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.897	.332		5.707	.000
	Prospective DRMA	-.063	.040	-.079	-1.567	.118
	Corrective DRMA	.131	.040	.166	3.283	.001
	Compensatory DRMA	-.010	.050	-.010	-.205	.838
	Community Based DRMA	.080	.076	.053	1.052	.294

Dependent Variable: Food crop production

Source: Field data (2023)

The analysis from Table 7.5 shows that prospective disaster risk management approach is statistically not significant 0.118 at $p > 0.05$, corrective disaster risk management approach is statistically significant 0.001 at $p < 0.05$, Compensatory disaster risk management approach is not statistically significant 0.838, and community based disaster risk management approach also being not statistically significant 0.294 at $p > 0.05$. The results hence show that among the approaches tested, it's just corrective disaster risk management approach that show positive strong level of significance, followed by prospective disaster risk management approach, community based disaster risk management approach, and compensatory disaster risk management approach respectively. The study therefore revealed that among the disaster risk management approaches tested, it's just corrective disaster risk management approach that has significant effectiveness in enhancing food security among households in the study area.

The study established that majority of the respondents mainly acted to the on the realization of the negative impact of climate change therefore taking a reactive measure to reduce the risk of extensive losses from climate change. Therefore, this confirms that most respondent related mainly with corrective disaster risk management approach to mitigate climate change to reduce the losses on food crop production in the study area. This finding resonates with GoK (2023) Siaya county climate change Action plan (2023-2028) and MoALF (2016) Siaya county climate risk profile that most small-scale farmers in the study are mainly involved in on farm such as crop rotation, diversification, growing drought tolerant crops and application of supplemental irrigation compared to the off-farm strategies such as early warning information. This therefore possibly made the respondent's rate corrective above other approaches efficacy towards food crop production improvement.

7.6.2 Collective effectiveness of the disaster risk management approaches towards food crop production in Siaya County

The study sought to conduct an inferential test on cumulative effectiveness of the disaster risk management approaches towards food crop production in Siaya County

Table 7.6: Effectiveness of the Disaster Risk Management Approaches to food crop production in Siaya County

		DRMA	Food crop production
Pearson Correlation	DRMA	1.000	.070
	Food crop production	.070	1.000
Sig. (1-tailed)	DRMA	.	.087
	Food crop production	.087	.
N	DRMA	385	385
	Food crop production	385	385

Source: Field data (2023)

The analysis in Table 7.6 shows that collectively, there is a positive relationship though weak correlation coefficient of 0.07 implying that increased application of the disaster risk management approaches had an increased effect on food crop production. However, the analysis did not exhibit a statistically significance at 0.087, $p > 0.05$ level of significance. The analysis revealed that the disaster risk management approaches have a positive effect but do not contribute significantly to enhancement of household food crop production under the changing climate in Siaya County. Many studies have been conducted however in isolation of different approaches or individual activities under a given approach Mogaka *et al*., (2021) making findings from this part of analysis that tested cumulative effectiveness of all the disaster risk management approaches not easy to compare with any on climate change mitigation for improved food crop production.

CHAPTER EIGHT

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter summarizes results of the study, derives conclusions and provides recommendations for appropriate programs and policy interventions by the national and county governments and other organizations working on climate related disaster risk reduction and food crop production. This chapter also suggests for further research areas.

8.2 Summary of the findings

This research purposed to investigate the influence of disaster risk management approaches on food crop production under the changing climate in Siaya County. In relation to objective one which was to establish the socio-economic characteristics which influence disaster risk management approaches applied in Siaya county, findings show that age had a correlation coeficient of 0.594 indicating a moderately positive relationship which was statistically significant at 0.045 ($P<0.05$), Gender had a correlation coefficient of 0.610 indicated a strong positive relationship which was statistically significant at 0.023, $p < 0.05$, Marital status had a correlation coefficient of 0.899 indicating a very strong positive relationship which was statistically significant at 0.008, $p<0.05$, Education level showed a correlation of 0.072 that indicated a very weak positive relationship which was not statistically significant at 0.697, $p > 0.05$, Occupation had a correlation coefficient of 0.537 that showed a moderate positive relationship which was significant at 0.046, $p < 0.05$, Years of residence had a correlation coefficient of 0.880 showing a very strong positive relationship which was significant at 0.048, $p < 0.05$, Monthly income had a correlation coefficient of 0.523 showing a moderate positive relationship that was statistically significant at 0.035, $p < 0.05$, Family size had a correlation coefficient of 0.456 that showed a weak positive relationship that was not statistically significant at 0.423, $p > 0.05$, and lastly Land tenure which had a correlation coeficience of 0.878 which showed a strong positive relationship with disaster risk management approaches with a significance level of 0.050, $p=0.05$.

Second objective determined the disaster risk management approaches that are mostly related to climate change mitigation, the study found out that Prospective disaster risk management approach had a positive though weak relationship $r = 0.21$ giving a significance with a p – value 0.044 ($P<0.05$); Corrective disaster risk management approach indicating a stronger positive relationship $r = 0.95$ giving a high significance value p – value 0.001 ($p < 0.05$); Compensatory disaster risk management approach, indicating a weak positive correlation $r = 0.002$ with a none significant value $p = 0.52$ ($p > 0.5$); while Community based Disaster risk management approach also indicated a positive but a weak correlation $r = 0.692$ with a significance value $p = 0.031$ ($p < 0.05$).

Third objective determined the relationship between the climate trends and food crop production. Analysis indicated that there was a negative, relatively stronger relationship where occurrence of drought episodes in the period under study reduced cumulatively annual food crops in Siaya County relating to a correlation coefficient of -0.540. Level of significance 0.05, $p = 0.05$ indicating a close association that the drought occurrences influenced negatively the annual food production reducing the yields of total food crop produced to 288,990,9 metric tons hence having possibility of contributing to food insecurity in Siaya County. The study also conducted a correlation analysis to establish the relationship between the flood trends and cumulative food crop production. There was a correlation coefficient of 0.507 illustrating a positive relationship. A 2 tailed significance level of 0.164 was exhibited with p value > 0.05 hence presenting lack of statistical significance in the relationship between cumulative food crop production and flood trends probability in Siaya County.

The fourth objective evaluated the effectiveness of disaster risk management approaches towards enhancing food crop production. The study established that out of the four approaches, only corrective disaster risk management approach indicated statistical significance effectiveness to food crop production at 0.001significance $p < 0.05$, while prospective, compensatory and community-based disaster risk management approaches at 0.118, 0.838 and 0.294 respectively $p > 0.05$ showed no statistical significance effectiveness to food crop production. The study further established that collectively, the approaches are not statistically significant 0.087 at $p > 0.05$ level of significance. The analysis therefore reveal that the disaster risk management approaches have a positive effect but do not contribute significantly to enhancement of household food crop production under the changing climate in Siaya County, Kenya.

8.3 Conclusions

The following conclusions were made based on the findings of the study:

Overall conclusion is that, the disaster risk management approaches have a positive effect but do not contribute significantly to the enhancement of household food crop production under the changing climate in Siaya County. This was exhibited by the analysis where there was a positive relationship though weak correlation coefficient of 0.07 implying that increased application of the disaster risk management approaches had an increased effect on food crop production. However, the analysis did not indicate any statistical significance at 0.087, $p > 0.05$ level of significance.

Specific to the findings from objective i, ii, iii, and iv of the study;

All the socio-economic factors in Siaya County had a positive influence to disaster risk management approaches application to mitigate climate change. However, marital status, gender and monthly income 0.008, 0.023 and 0.035 respectively p value < 0.05 significantly influenced the practices of disaster risk management approaches compared to age, occupation, year of residence and land tenure at 0.045, 0.046, 0.048 and 0.05 respectively p value < 0.05. Contrary, family size, and education of the respondents at 0.423, and 0.697 respectively, p value > 0.05 though positive, had no significant influence on the disaster risk management approaches applied in mitigating climate change for the improvement of food crop production in the study area.

In Siaya County, all the disaster risk management approaches show positive association with climate change however, corrective disaster risk management approach show highest positive relationship $r = 0.95$, p value at 0.001 ($p < 0.05$) indicating that households prefer it with indicators as drought tolerant crops, soil and water management strategies, and crop diversification, over the other approaches in mitigating the negative impacts of climate change on food crop production.

There is a strong negative relationship between climate trends (drought) and food crop production where, an increased trend in drought reduced annual food crop production to 288,990,9 metric tons in the study period. However, floods and food crop production had a relatively positive relationship where, annual food crop yield wasn't adversely affected from a total of 288, 990, 9 metric tons despite flood occurrences over the years under study in Siaya County.

Disaster risk management approaches have a positive association to crop yield however, the findings reveal that it was only corrective disaster risk management Approach that had a significant contribution to increased yield as compared to the rest that lacked statistical significance indicating not effective to enhancement of annual food crop production under the changing climate in Siaya County.

8.4 Recommendations

The study showed varying trends of various socio-economic factors influencing disaster risk management approaches for food crop production in Siaya County. There is therefore need for concerted efforts by various stakeholders in food crop production and disaster risk reduction such as Ministry of Agriculture to consider socio-economic factors when planning for interventions and advocate for application of the disaster risk management approaches to mitigate agricultural risks from the changing climate for sustainable food crop production.

Findings revealed that out of four disaster risk management approaches, only corrective disaster risk management approach was significantly related to climate change and this was as a result of reduced capacities in terms of resources used to practice the risk reduction activities such as crop diversification, soil and water management and drought tolerant cropping under this approach by the households. There is therefore need for strengthening the capacities of the small-scale farmers in terms of training and knowledge by relevant authorities and organizations to enhance implementation of the other three approaches as prospective, compensatory and community based in climate change risk management in Siaya County.

Evidently, climate trends through drought episodes and floods occurrence and recurrence impacted food crop production therefore affecting the households' food security. There is therefore need for relevant stakeholders such as KALRO to increase sensitization of households on suitable crops for suitable seasons and regions with guidance from the Agricultural Ecological Zones to reduce risks of household food insecurity from flooding and drought.

The disaster risk management approaches are not effective to enhancement of food crop production. There is need for a multi-stakeholder approach for collective implementation of all the approaches to ensure a wholesome achievement of the goals of the disaster risk management approaches; to prevent, reduce the risks, transfer the risk and ensure effective community involvement in mitigating climate change risks in the entire agricultural system for sustainable food crop production in Siaya County.

8.5: Suggested areas for further research

i) This research suggests for study that compare crop production in different Agro – Ecological Zones under the changing climate in Siaya County.

ii) This research suggests for a study on spatial and temporal vegetation cover and their influence on food security in Siaya County.

iii) This research suggests for a study on socio economic determinants of early warning response to floods for crop production in the Nzoia basin.

iv) This research suggests for a study on influence of the existing water bodies on flooding the surrounding locations Siaya County

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APPENDICES

Appendix I: Household Questionnaire

Dear Respondent

My name is Japheth Ogenga, a student at Masinde Muliro University of Science and Technology pursuing a Ph.D. in Disaster Management and Sustainable Development. I am conducting academic research on the influence of Disaster risk management approaches on food security under the changing climate in Siaya County. The study will inform the community and other stakeholders on the appropriate risk management approaches in enhancing food security under the changing climate. The information received from the respondents will be treated with utmost confidentiality. I therefore kindly seek for your assistance in gathering data on it.

Kindly tick in the space provided (√) the correct answers or give the required information where specified.

A. Demographic information		
1	Residence (Please fill in the Space provided)	....
2	Household head age brackets	1. (18 – 22) 6. (43 – 47) 2. (23 – 27) 7. (48 – 52) 3. (28 – 32) 8. (53 – 57) 4. (33 – 37) 9. (58 – 62) 5. (38 – 42) 10. (63 – 67) 11. >68
3	Gender of Household Head	1. Male ( ) 2. Female ( )
4	Marital Status	1.Single ( ) 2.Married ( ) 3. Widowed ( ) 4.Others(specify) ( )
5	Education	1. Primary level ( ) 2. Secondary level ( ) 3. Tertiary level ( ) 4. University level ( )
6	What is your Occupation	1. Farming ( ) 2. Fishing ( ) 3. Business ( )

		4.Others ( ) (Specify) ………………….
7	Years of residence	(1 – 5) { } (6 – 11) { } (12-17) { } (18-23) { } (24-29) { } (>30) { }

B). To determine the disaster risk management approaches related to climate change in Siaya County, Kenya

8. Do you believe that there are effects of climate change on food security in this area? (Tick appropriately)

i) Yes............. ii). No..................................

If yes, from what climatic hazard mostly in your area?
Floods ( )
Drought ( )
Pest and diseases ( )

9. How frequent does the climate characteristics occur in this area?

Climatic hazard	Seasonally	Twice a year	Annually
Floods			

10. How long does the climatic hazard take when it occurs in the area?

Climatic hazard	One month	Three months	Six months	One year	Over 1 year
Drought					

11). Which disaster risk management approaches activity do you mostly use to mitigate climate change and impacts?

Prospective risk management approaches		
S/N	**Activities**	**Mark**
1	GHG emission reduction activities	
2	Land use planning	
3	Agro-forestry	
5	Early warning	
6	**Others …………………………………………….**	
Corrective risk management approach activities		
1	Supplemental irrigation	
2	Planting of drought tolerant crops	
3	Pest and diseases management	
4	Crop diversification	

5	Improved food crop storage	
6	Dyke construction	
Compensatory risk management activities		
1	National contingency funds	
2	Contingent credit	
3	Insurance of crops and livestock	
4	Safety nets such as cash transfer programs	
5	**Others ……………………………………….**	
Community – based risk management activities (involvement)		
1	Food insecurity Risk analysis	
2	Planning of the risk reduction activities	
3	Implementation of the risk reduction activities	
4	Monitoring of the implementation of the risk reduction activities	
5	**Others …………………………………………**	

C. Food production in different climatic seasons

12. How much food do you produce in a normal year in bags/ Liters?

1	Maize	
2	Beans	
3	Sorghum	
4	Sweet potatoes	
5	Cassava	

13. How much food is produced in a year with extreme droughts condition in bags/Liters?

1	Maize	
2	Beans	
3	Sorghum	
4	Cassava	
5	Sweet potatoes	

14. How much food is produced in a year with extreme flood condition in bags/Liters?

1	Maize	
2	Beans	
3	Sorghum	
4	Cassava	
5	Sweet potatoes	

D. To establish the effectiveness of the disaster risk management approaches on food security in Siaya County, Kenya

15. In your opinion, are the listed approaches contributed increased food crop production in the area? (**N.E**-Very Effective, **E**-Effective, **L.E**- Less effective, **N.E**-Not effective, **N.A-** Not aware)

Prospective risk management approaches		**V. E**	**E**	**L. E**	**N. E**	**N.A**
S/N	**Activities**					
1	GHG emission reduction activities					
2	Land use planning					
3	Afforestation					
5	Early warning					
6	**Others ………………………………………**					
Corrective risk management approach activities						
1	Supplemental irrigation					
2	Planting of drought tolerant crops					
3	Pest and diseases management					
4	Crop diversification					
5	Improved food crop storage					
6	Dyke construction					
Compensatory risk management activities						
1	National contingency funds					
2	Contingent credit					
3	Insurance of crops and livestock					
4	Safety nets such as cash transfer programs					
5	**Others ……………………………………….**					
Community – based risk management activities (involvement)						
1	Food insecurity Risk analysis					
2	Planning of the risk reduction activities					
3	Implementation of the risk reduction activities					
4	Monitoring of the implementation of the risk reduction activities					
5	**Others ………………………………………**					

Appendix II: Key Informant Interview guide

1. Do you believe that there are effects of climate change on food crop production in this area?

2. If yes, from what climatic hazard mostly in your area?

3. How frequent does the climate characteristics occur in this area?

4. How long does the climatic hazard take when it occurs in the area?

5. When these hazards occur how intense are they? Use Likert scale i.e. Normal, moderate, severe, and very severe

6. Which are some of the disaster risk management approaches you mostly use to mitigate climate change and impacts?

Avoid climate change risk on food crops

Reduce climate change risk on food crops

Recover from climate change risk on food crops

Enhance community participation towards vulnerability reduction

7. What is the food security status in your area of residence (normal, reduced, and increased?)

8. How long does food take in the households from the last harvest?

9. How many eating occasions do you have in a day normally?

10. Which are some of the food groups mostly consumed in your households for main meal in a week?

11. In your opinion how effective are the disaster risk management approaches on food crop production in the area?

12. Who are the main actors in initiating disaster risk management approaches on food crop production in Siaya County, Kenya?

Appendix III: Focus Group Discussion Guide

1 Do you believe that there are effects of climate change on food security in this area?

2. If yes, from what climatic hazard mostly in your area?

3. How frequent does the climate characteristics occur in this area?

4. How long does the climatic hazard take when it occurs in the area?

5. When these hazards occur how intense are they? Use Likert scale i.e. Normal, moderate, severe, and very severe

6. Which are some of the disaster risk management approaches you mostly use to mitigate climate change and impacts?

Avoid climate change risk on food crops

Reduce climate change risk on food crops

Recover from climate change risk on food crops

Enhance community participation towards vulnerability reduction

7. What is the food crop production status in your area of residence (normal, reduced, and increased?)

8. How long does food take in the households from the last harvest?

9. How many eating occasions do you have in a day normally?

10. Which are some of the food groups mostly consumed in your households for main meal in a week?

11. In your opinion how effective are the disaster risk management approaches on food crop production in the area?

12. Who are the main actors in initiating disaster risk management approaches on food crop production in Siaya County, Kenya?

Appendix IV: Average Temperature for the period (1991 – 2021) in Siaya County

No	Year	Average Temperature (0^c)
1	1991	28
2	1992	27.7
3	1993	28.3
4	1994	28.2
5	1995	28.7
6	1996	28.15
7	1997	28.3
8	1998	27.9
9	1999	28.6
10	2000	28.5
11	2001	28.3
12	2002	28.5
13	2003	27.9
14	2004	28.6
15	2005	28.3
16	2006	28.2
17	2007	28.8
18	2008	28.5
19	2009	28.5
20	2010	28.0
21	2011	28.2
22	2012	28.3
23	2013	28.3
24	2014	28.2
25	2015	28.4
26	2016	28
27	2017	28.7
28	2018	28.2
29	2019	28.4
30	2020	27.6
31	2021	27.7

Source: Siaya weather station and Kenya Meteorological Department Headquarters (2023)

Appendix V. Average rainfall amount in Siaya County

No	Year	Average annual Rainfall amount (mm)
1	1992	130.52
2	1993	125.68
3	1994	168.31
4	1995	155.57
5	1996	156.01
6	1997	162.16
7	1998	106.35
8	1999	117.33
9	2000	101.95
10	2001	168.31
11	2002	155.13
12	2003	134.47
13	2004	124.81
14	2005	94.92
15	2006	156.44
16	2007	126.12
17	2008	131.40
18	2009	128.32
19	2010	154.69
20	2011	159.52
21	2012	143.70
22	2013	130.96
23	2014	112.50
24	2015	196.88
25	2016	94.48
26	2017	159.08
27	2018	173.58
28	2019	209.18
29	2020	223.68
30	2021	142.81

Source: Siaya weather station and Kenya Meteorological Department Headquarters (2023)

Appendix VI. Food crop production yield in Metric tons in Siaya County

Year	Maize	Sorghum	Beans	Sweet potatoes	Cassava
2012	130682	15955	25530	15500	57600
2013	129818	21081	28262	13680	59400
2014	145955	20091	31203	15700	70000
2015	150030.1	10847.04	24371	41487	55018
2016	117053	18407.92	26699	64735	71846
2017	81669.53	17059.6	24344	45208	39632
2018	87638.45	22324.45	14685.84	54090	35024
2019	75732.95	16288.1	17820.2	47455	34424
2020	71299	10066	16271	78903	54500
2021	55296	13845	17129	45842	53475
2022	56661	13846	15855	48282	51594
Aver.	100166.8	16346.46	22015.46	42807.45	52955.73
SD	35375.19	3991.066	5786.532	20756.22	12496.81

Source: Department of Agriculture, irrigation, Livestock and Fisheries, Siaya County (2023)

Appendix VII. Research Proposal approval by Directorate of Post graduate Studies

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: directordps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

31st October ,2022

Ogenga Japheth Omule
CDS/H/01 – 53106/2018
P.O. Box 190-50100
KAKAMEGA

Dear Mr. Omule,

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your PhD proposal entitled: "***The Influence of Disaster Risk Management Approaches on Food Security Under the Changing Climate in Siaya County, Kenya***" and appointed the following as supervisors:

1. Prof. Josephine K. W. Ngaira - SDMHA - MMUST
2. Dr. Edward Mugalavai - SDMHA - MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director of Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Disaster Management and Humanitarian Assistance Graduate Studies Committee and Chairman, Department of Disaster Management and Sustainable Development. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your PhD thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours sincerely,

Prof. Stephen O. Odebero, PhD, FIEEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

Appendix VIII: Research Permit from NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 970429

Date of Issue: 06/December/2022

RESEARCH LICENSE

This is to Certify that Mr.. JAPHETH OMULE OCENCA of Masinde Muliro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Siaya on the topic: INFLUENCE OF DISASTER RISK MANAGEMENT APPROACHES ON FOOD SECURITY UNDER THE CHANGING CLIMATE IN SIAYA COUNTY, KENYA for the period ending : 06/December/2023.

License No: NACOSTI/P/22/22230

970429

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix IX: Research authorization from the County Director of Education, Siaya

REPUBLIC OF KENYA
MINISTRY OF EDUCATION
State Department For Basic Education

COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
P.O. BOX 564
SIAYA

E-mail:cdesiaya2016@gmail.com
MOE/SYA/CDE/URA/1/10/VOL.II/87

Monday, March 20, 2023

TO WHOM IT MAY CONCERN

RESEARCH AUTHORIZATION - JAPHETH OMULE OGENGA – MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY

The above-named person has been mandated to carry out research in Siaya County vide research License No. **NACOSTI/P/22/22230** dated 6th December, 2022 for the period ending 6th December, 2023.

The research title is "***Influence of Disaster Risk Management Approaches on Food Security Under the Changing Climate.***"

Please accord him the necessary assistance as he may require.

ALBERT ALUSO
FOR: COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY

FOR
COUNTY DIRECTOR OF EDUCATION
20 MAR 2023
SIAYA COUNTY
P. O. Box 564 - 4060, SIAYA

SGS

Appendix X: Research authorization from the County Commissioner, Siaya

REPUBLIC OF KENYA

OFFICE OF THE PRESIDENT

MINISTRY OF INTERIOR & NATIONAL ADMINISTRATION

E-Mail cc.siaya@yahoo.com
When replying please quote ref. & date

COUNTY COMMISSIONER
SIAYA COUNTY
P O Box 83-40600
SIAYA

CC/SC/A.31 VOL.IV/111

17th March, 2023

All Deputy County Commissioners
SIAYA COUNTY

RE: RESEARCH AUTHORIZATION – MR. JAPHETH OMULE OGENGA

The person referred to above from Masinde Muliro University of Science and Technology, has been authorized by the Director General, National Commission for Science, Technology and Innovation vide letter Ref.no *NACOSTI/P/22/22230/*970429 dated 06th December 2022 to carry out research on "***Influence of disaster risk management approaches on food security under the changing climate***", for the period ending **06th December, 2023**.

The purpose of this letter therefore is to ask that you accord him the necessary support as he carries out research in your Sub County.

NOTE: Due to the prevailing COVID - 19 situation, he must observe containment protocols as directed by Ministry of Health.

RODAH CHERUS
For: COUNTY COMMISSIONER
SIAYA COUNTY

Copy to; JAPHETH OMULE OGENGA
Masinde Muliro University of Science and Technology