

**EFFECTIVENESS OF AGRICULTURAL EXTENSION IN ADOPTION OF
CLIMATE CHANGE ADAPTATION TECHNOLOGIES AMONG
SMALLHOLDER FARMERS IN NYATIKE SUB-COUNTY, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfillment of the
Requirements for the Award of Degree of Master of Science in Agricultural
Extension of Chuka University**


CHUKA UNIVERSITY

OCTOBER 2024

DECLARATION AND RECOMMENDATIONS

Declaration


This thesis is my original work and has not been submitted for an award of a diploma or conferment of degree in any institution.

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Recommendation

This thesis has been examined, passed and submitted with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my Husband Dr. Julius Nyerere and sons Ethan and Ezra Nyerere.

ACKNOWLEDGEMENT

I am thankful to God for granting me the grace to complete my research work. I extend my heartfelt appreciation to my supervisors, for their invaluable guidance, advice, and encouragement during the research process and the writing of the thesis. Their insightful feedback as my academic mentors throughout the study has been truly remarkable.

I also want to express my deep gratitude and respect to my mother Silpha and late dad Raphael Anyuor, for their financial and moral support throughout this research. I am grateful to the department of Agricultural Sciences Chuka University, colleagues and my fellow students and friends for their unwavering assistance during the study. I also acknowledge the support of my husband, Dr. Julius Nyerere and sons Ethan and Ezra Nyerere. I appreciate the study participants for their active involvement in this research and extend my thanks to everyone who contributed to the successful completion of this thesis.

ABSTRACT

Adaptation is a crucial component of the long-term global response to climate change, necessary for protecting people, livelihoods, and ecosystems. It is imperative for countries and communities to devise adaptation strategies and take proactive measures to address both current and anticipated impacts of climate change. Although agricultural extension services have promoted best practices and technologies to enhance the adaptive capacity and resilience of farming communities, the adoption of climate change adaptation practices remains low among farmers, especially in developing countries. This low adoption rate may be attributed to limited awareness of climate change and the use of ineffective extension approaches for disseminating information on adaptation practices. Moreover, relatively few studies have examined the weaknesses and suitability of the methods and approaches used by agricultural extension agents to help farmers effectively manage climate risks. Therefore, this study aimed to determine the effectiveness of agricultural extension in the dissemination and adoption of climate change adaptation practices among farmers. The study focused on 26,354 smallholder farmers residing in Kachieng, Kanyasa, Macalder, Muhuru, Kaler, Got-Kachola, and North-Kadem wards. Data were collected using a pretested semi-structured questionnaire administered to a sample of 395 households selected through cluster sampling. A pilot study was conducted in Suba South, and the research instrument was found to be reliable. Data were processed and analyzed using SPSS version 25, with results summarized using descriptive and inferential statistics. The influence of awareness and the use of interpersonal and mass media extension channels on the adoption of adaptation practices was tested using Analysis of Variance and ordinal logistic regression respectively, while Spearman's rank correlation was employed to determine the effect of the project-based approach on adoption. The results indicated that 98% of respondents perceived changes in weather patterns. Awareness level had a significant influence on adoption of adaptation practices at $p < 0.05$ for the three levels ($F(2, 392) = 11.389, p = 0.00$). The effect size was 0.07 indicating a moderate effect of awareness level of adoption of adaptation practices. Post hoc comparisons revealed that the mean adoption level for the highly aware group ($M = 137.29, SD = 29.35$) was significantly ($p < 0.05$) higher than the aware ($M = 121.70, SD = 31.03$) and the undecided group ($M = 112.85, SD = 45.95$). Access to adaptation information through interpersonal channels (Coefficient = 1.957, SE = 0.449, Wald $\chi^2 = 18.975, p < 0.05$) and mass media channels (Coefficient = 2.123, SE = 0.467, Wald $\chi^2 = 0.069, p = 0.012$) was significantly associated with the adoption of climate adaptation practices, the effectiveness of the project-based extension approach was positively correlated with the adoption of adaptation practices ($\rho = .31$). The study concluded that awareness of climate impacts, the use of mass media and interpersonal extension methods, and the project-based approach influenced the adoption of climate adaptation practices. However, the project-based approach was only moderately effective, indicating the need for more diverse, context-specific projects based on thorough needs assessments and intensive involvement of local communities. To promote timely and effective dissemination of climate adaptation information to farmers, a combination of extension communication channels and approaches is recommended.

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LIST OF ACRONYMS

CBA:	Community Based Agroforestry
CCAA:	Climate Change Adaptation Action
CIDP:	County Assembly Integrated Development Plans
CSA:	Climate Smart Agriculture
DaCCA:	Devolution and Climate Change Adaptation
GHG:	Greenhouse Gases
IPCC:	Intergovernmental Panel on Climate Change
KALRO:	Kenya Agriculture and Livestock Research Organization
NAPCC:	National Action Plan on Climate Change
NCCRS:	National Climate Change Response Strategy
SRCC:	Strengthening Resilience to Climate Change
UNEP:	United Nations Environmental Program
UNFCCC:	United Nations Framework on Climate Change Convention

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Adaptation to climate change is an urgent and imperative necessity for developed and developing countries (Bellon & Massetti, 2022; Fankhauser, 2017). Adaptation is essential to address the risks arising from alterations in average climatic conditions and increased frequency and intensity of extreme weather fluctuations. Strengthening communities' capacity to adapt to these risks is crucial for reducing vulnerability and effectively managing adverse climate change outcomes. Effective adaptation entails the development of a comprehensive list of potential strategies and actions that serve as a roadmap for managing the challenges posed by climate change (United Nations, 2020).

Enhancing resilience to climate impacts in agriculture, such as the emergence of new species, shifts in rainfall patterns, increased frequency of floods and droughts, and disruptions to ecological processes, requires the implementation of adaptation practices. Some of these practices include optimizing water resources, making infrastructure more resilient to extreme weather, and implementing effective land-use planning strategies (Berrang-Ford *et al.*, 2019). However, the spectrum of these adaptation strategies extends from individual to local, national, and global efforts. (Lempert *et al.*, 2018). Before designing adaptation strategies, it is crucial to acknowledge that the impacts of climate change and the associated socio-economic consequences vary significantly from country to country and within regions of a particular country. Therefore, adaptation responses are multifaceted and highly dependent on geographical, topographical, and socio-cultural context (United Nations, 2020).

In the United States, the awareness of climate-related threats, impacts, and associated risks has increased adaptation efforts. The growing recognition is driven by the understanding that investing in adaptation mitigates risks and yields economic and social benefits that exceed extreme events' costs, frequency, and magnitude (Lempert *et al.*, 2018). The Environmental Protection Agency (EPA) plays a significant role in climate change adaptation, planning, and implementation of working strategies. In its approach to climate change, the agency considers various entry points, including

developing and enforcing policies and compliance assurance and engaging with stakeholders, particularly the overburdened and underserved communities more susceptible to climate impacts. The EPA focuses on safeguarding human health and the environment by reducing risks from climate change impacts while working towards mitigation through reducing greenhouse gas emissions (Environmental Protection Agency, 2021). In Europe, China, and Indonesia, adaptation efforts involve the active participation of local governments, which are pivotal in shaping policies and allocating resources for implementing adaptation strategies (He *et al.*, 2022). China has shown dedication to promoting sustainable agricultural practices like precision farming and implementing water conservation measures such as water pricing (Chen & Gong, 2021). These initiatives aim to improve food security and reduce vulnerability in the agricultural sector.

In Africa, the urgency to effectively address projected climate-related risks has prompted several countries, including Botswana, Egypt, Eritrea, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Malawi, Namibia, and Nigeria, to implement a range of adaptation measures, particularly in the agricultural sector (Oguge *et al.*, 2021). These measures encompass conservation agriculture, capacity building, research, water management, irrigation, and flood management (Mekuyie & Mulu, 2021). Furthermore, there has been an increase in resource allocation towards adaptation efforts, including implementing donor-funded projects (Currie-Alder *et al.*, 2020; Gaisie & Cobbinah, 2023). For instance, in Gambia, the government and the United Nations Environmental Program have collaborated on a large-scale ecosystem-based adaptation initiative in forestry to address climate change impacts (UNEP, 2020).

However, adopting these measures faces various challenges, including financial constraints, lack of supportive policies, limited knowledge and awareness, and slow dissemination of innovations (Muchuru & Nhamo, 2019; Suvedi *et al.*, 2023). Consequently, Africa remains vulnerable to the impacts of climate change, primarily due to the limited capacity for adaptation, particularly among smallholder farmers who heavily rely on natural water systems that are susceptible to climate variability (Mekuyie & Mulu, 2021; Amaranto *et al.*, 2022; Kamali *et al.*, 2022). This necessitates collaboration among stakeholders, primarily farmers, policymakers, extension agents,

non-governmental organizations (NGOs), researchers, communities, and the private sector to promote and support adaptation practices, particularly among producers (Mekuyie & Mulu, 2021).

Kenya has made substantive strides in prioritizing adaptation through policy interventions, creating an enabling environment, allocating resources, and implementing the National Climate Change Action Plan [NCCAP] (Chaudhury *et al.*, 2020). The primary objective is to counter the adverse socio-economic impacts in response to the projected threats. County governments have cooperated by integrating and mainstreaming climate adaptation through the County Assembly Integrated Development Plans [CIDPs] (GoK, 2016). The CIDPs require the extension department to design activities aimed at building resilience in the agriculture sector through education and training, promoting climate-smart agriculture practices, raising awareness at the farm level, and capacity building among stakeholders. Furthermore, farming households nationwide have been implementing various climate adaptation technologies, such as planting early maturing varieties, agroforestry, and adopting other crop and livestock management practices (Nyiwul, 2021).

Adapting to climate change requires changing people's behavior, knowledge, and skills. This is largely achieved in agriculture through the provision of extension services. These services encompass the creation of awareness, provision of practical skills and knowledge, as well as changing farmers' attitudes. (Machingura *et al.*, 2018; Ofoegbu & New 2021; Agwu *et al.*, 2023). The importance of extension services in enhancing farm adaptation to climate change must be balanced (Anshuman *et al.*, 2022; Nair *et al.*, 2023). Extension systems vary considerably worldwide, influencing the choice and integration of extension personnel's approaches and methods. These approaches can be categorized as delivery or acquisition approaches, including the training and visit, commodity-specific, and project-based educational institutions approaches (Bernard *et al.*, 2019; Otieno *et al.*, 2021). These have been used to promote the dissemination of climate information.

Most of the county extension departments in Kenya have achieved significant progress in promoting climate adaptation strategies through comprehensive planning, policy

formulation, and enabling programs and projects (Baker *et al.*, 2018). The most popular approach applied in most parts of the country by extension personnel for training farmers on appropriate adaptation strategies is project-based. The approach involves the design and execution of projects aimed at enhancing resilience to climate change. Notable examples of such projects in Western Kenya include the Devolution and Climate Change Adaptation program (DaCCA) and the Strengthening Resilience to Climate Change project (SRCC), among others (Migori County Government, 2020).

These projects involve extension methods such as farmer training programs, field days, demonstrations, exhibitions, and dissemination of climate change-related information through mass media (Otieno *et al.*, 2021). In Nyatike Sub-county, the extension agents, in collaboration with national and international agencies, have been at the forefront of promoting the adoption of agroforestry practices under Community Based Agroforestry (CBA), the installation of water harvesting technologies, promotion of climate-smart agriculture, and community-based disaster risk reduction to help the communities manage climate change (Odhiambo *et al.*, 2019; Mwambeo *et al.*, 2022). These practices are designed and implemented majorly through donor-funded projects.

Despite the presence of extensive evidence showcasing the widespread advantages of adaptation, there are indications that farmers' reactions to climate risks could be more consistently effective (Albright *et al.*, 2020). Moreover, numerous instances of inadequate adoption of adaptation practices among farmers in the sub-county have been observed. This situation can be attributed to ineffective extension approaches and diffusion methods, which impede farmers' access to crucial information on climate change adaptation. Although research on climate change adaptation is growing in volume and sophistication, the effectiveness of extension approaches and methods utilized in disseminating adaptation practices have received little attention from researchers. Previous research has primarily focused on the role of extension in raising awareness and disseminating accurate weather data without sufficiently highlighting the rate of climate change adaptation (Davidson *et al.*, 2019). More research is needed to demonstrate the efficacy of the project-based and embedded extension approaches (Otieno *et al.*, 2021). Previous research findings on the effectiveness of extension have

also been inconclusive due to variations in the structure of extension services across different regions (Sikhondze, 2020; Anshuman *et al.*, 2022).

The successful adoption of the adaptation practices depends on the effectiveness of the extension methods utilized and the skills of the extension personnel (Eta *et al.*, 2022). Therefore, knowing the most efficient methods that would assist in the effective diffusion of information to increase the adoption of adaptation practices is worthwhile. Overall, understanding the value of extension services in promoting the adoption of practices that enhance the resilience and adaptive capacity of the communities living in the region was crucial for policy formulation.

1.2 Statement of Problem

Despite the significant role of agricultural extension in disseminating information and promoting technology adoption, it has not been successful in effectively facilitating farmers' adaptation to climate change. The lack of success is evident from low adoption rates and the continued vulnerability of smallholder farmers to climate risks such as loss of livestock, pests and disease invasion, and perennial floods. The effectiveness of agricultural extension in delivering adaptation information has therefore been questioned. While several projects have been initiated to facilitate farmer adaptation to climate change by disseminating climate adaptation technologies with minimal success. Previous studies have primarily focused on the role of extension services in raising awareness of climate change impacts and building the capacity of extension agents. This study was conducted to identify the weaknesses and suitability of the project-based approach to climate adaptation and channels used by agricultural extension agents in promoting adoption of climate adaptation technologies information, especially in the Nyatike sub-county.

1.3 Objectives of the Study

1.3.1 General Objective

To examine the effectiveness of agricultural extension in disseminating and adopting climate change adaptation practices among smallholder farmers in Nyatike Sub-County.

1.3.2 Specific Objectives

The study was anchored on the following key objectives:

- i. To assess the influence of awareness of climate change impacts on adoption of climate change adaptation practices.
- ii. To determine the effect of extension delivery channels on adopting climate change adaptation practices.
- iii. To determine the effectiveness of the project-based extension approach in enhancing the adoption of climate change adaptation practices.

1.4 Research Questions

- i. How does awareness of climate change impacts influence adoption of climate change adaptation practices?
- ii. How does the extension delivery channels used affect adoption of climate change adaptation practices?
- iii. How does the use of the project extension approach influence the adoption of climate change adaptation practices?

1.5 Significance of the Study

Climate change is a global challenge that affects agricultural productivity, with smallholder farmers being more vulnerable to its impacts due to their limited adaptive capacity. Identifying effective ways of disseminating climate change adaptation practices to smallholder farmers was crucial, as that would enhance their resilience and food production. Extension services could be vital in providing information and technical support to farmers, especially in rural areas. As such, evaluating the effectiveness of extension in disseminating climate change adaptation practices would provide insights into the strengths and weaknesses of existing extension approaches and inform strategies for improving the provision of the services in the Sub-County. The information generated would clarify the degree to which the project-based extension approach could successfully disseminate information on climate adaptation technologies.

1.6 Scope of the Study

The study was undertaken in the Nyatike sub-county, targeting 26,354 smallholder farmers. Data was collected from a representative sample of 395 farmers across the seven wards: North-Kadem, Kachieng, Got-Kachola, Macalder, Kanyasa, Muhuru, and Kaler. Nyatike Sub-county was selected based on its dynamic agricultural activities, vulnerability to climate change impacts, and the urgent need to implement effective adaptation strategies among the growing number of smallholder farmers. The study focused on extension effectiveness and adoption of climate change adaptation practices, both public and private extension services. Specifically, the research covered how farmers' awareness of climate change impacts, the extension delivery channels, and the effectiveness of the project-based approach used in communicating adaptation practices influenced adoption of these technologies. The research was guided by the Diffusion of Innovation theory by Everett Rogers. The study was conducted between the months of September and October 2023.

1.7 Limitations of the Study

This study faced limitations due to smallholder farmers' difficulty in recalling specific information regarding the impact of climate change in previous years. To address this challenge, the researcher offered a range of climate change indicators to aid respondents' recollection. Additionally, the participants' educational background posed a hurdle in understanding the survey questions. To address this, the questions were translated into the local dialect, particularly for farmers with minimal or no formal education, facilitating better comprehension and participation in the study.

1.8 Assumptions of the Study

The study operated under the assumption that the agricultural extension system efficiently communicated climate change adaptation techniques to smallholder farmers in the Nyatike Sub-county, Kenya. Additionally, it presumed that the respondents would cooperate and offer accurate responses during the data collection process.

1.9 Operational Definition of Terms

Adaptation Technologies	These are strategies, actions, and measures implemented to mitigate and respond to the impacts of climate change, including land-water management and farm management techniques.
Adaptive Capacity	The potential of a system to respond successfully to climate variability and change includes adjustments in behavior resources and technologies. For this study, adaptive capacity was operationalized as the ability of individual farmers to effectively respond to climate impacts.
Agricultural Extension Approach	An agricultural extension organization's basic planning philosophy is to understand concepts and functional methods adopted to fulfill its mandate—simply the general organization or style of extension.
Climate Change Adaptation	This is the adjustment to current or expected climate change and its effects, including efforts to co-exist with the already felt climate impacts.
Climate Change Impact	Defined as the potential effects of change in climate parameters over a given period felt through unpredictable weather patterns.
Dissemination	This is the information on agricultural technologies and practices to a target population (Ballew <i>et al.</i> , 2019). For this study, dissemination would entail the communication of technologies among the immediate clientele of extension.
Project-based extension approach	Style of extension that concentrates the efforts on a particular location for a specific period with the aim of general rural development, the project is implemented based on the immediate needs of the rural population, the locals benefit from incorporated services and project outcomes.

Smallholder Farmers These are farmers with an arable open land area (Ballew *et al.*, 2019). In this study, a smallholder farmer was any farmer with arable land of below 5 acres.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Climate Change Adaptation

Climate change has been a prominent and extensively discussed issue in the 21st century, with significant economic and ecological implications. As climate change impacts are experienced globally, smallholder farmers in developing countries are among the most vulnerable groups. The Intergovernmental Panel on Climate Change (2022) has predicted that the global average temperature could rise by 1.5°C above pre-industrial levels as early as 2030 if greenhouse gas emissions remain at their current rate. This increase in temperature could result in several significant impacts on the planet, including rising sea levels, more frequent and intense extreme weather events, loss of biodiversity, and food and water scarcity (Wu *et al.*, 2019; Intergovernmental Energy Agency, 2021; Romanak *et al.*, 2021).

The concentration of greenhouse gases in the atmosphere is rising steadily, attributed to anthropogenic activities. As a result, the subtropical regions may become warmer than the moister tropics, with much of Mediterranean Africa, Northern Sahara, and Southern Africa expected to experience a decline in rainfall. Therefore, global warming, greenhouse gases, and limitations on carbon dioxide emissions are at the top of the political agenda as they constitute part of the pressing and momentous threats to the agricultural system (Kang & Eltahir, 2018; Abegunde *et al.*, 2019).

Research on climate change has shown that the East Africa region exhibits considerable climatic and topographic variability (Huang *et al.*, 2017; Park *et al.*, 2018). Furthermore, East Africa faces potential threats of climate variability and resulting aridity, contributing to land degradation and desertification. Kenya is experiencing climate change variability, leading to ice melting, rising ocean levels, high temperatures, and erratic rainfall patterns, as Cheng *et al.* (2023) reported. These climate variations are due to both maritime and terrestrial influences. Kenya has a seasonal rainfall pattern, with long rains from March to June and short rains from September to November or December (Ongoma *et al.*, 2019). This pattern is linked to altitude, leading to more erratic rainfall in arid and semi-arid regions. These changes have significant effects on the entire population, which mainly depends on rain-fed

agriculture, resulting in negative impacts on the economy, household nutrition, and food security in general (Amélineau *et al.*, 2018; Mulwa & Kabubo-Mariara, 2022).

Moreover, droughts have been a regular occurrence in various countries with drastic consequences on food security and nutrition. Severe droughts are likely to occur more often and affect most regions, particularly within Arid and Semi-Arid Lands (Abegunde *et al.*, 2019). Other areas like the Tana River basin and coastal areas also experience floods threatening agricultural productivity and infrastructure (Muthuwatta *et al.*, 2018). Nyatike sub-county in western Kenya is among the affected areas along the Lake Victoria basin, experiencing shifts in rainfall patterns leading to increased poverty which contributes to the pathetic household food security situation (Ojuok, 2020).

Future projections of climate change impacts have signaled the urgent force to create effective adaptation in the production sector to care for the rising population (Nunn *et al.*, 2021). Adaptation is "the adjustment in human and natural systems in response to actual or expected climatic variation to moderate harm or exploit beneficial opportunities" (IPCC, 2022). Climate change adaptation can be anticipatory, that is, an adaptation that takes place before the impacts of climate change are felt, and reactive adaptation, which takes place after the impacts of climate change have been felt. Ballew *et al.* (2019) reported that the impacts of climate change have been observed, leading to economic discussions on how best to adapt. As a result, the United Nations Framework Convention on Climate Change's Paris Agreement set three essential regulatory points for nations, including limiting global temperature rise to below two degrees Celsius, pursuing efforts to keep it under 1.5°C, and adapting to reduce the vulnerability of people and ecosystems to the effects of climate change (IPCC, 2018; United Nations, 2018).

According to Morecroft *et al.* (2019), an effective response to climate change would imply urgent measures to halt the rate of greenhouse gas emissions (GHG) and adopt working adaptation strategies to reduce the already felt climate change impacts greatly. However, in their study, Nunn *et al.* (2021) reported a need to understand farmers' awareness of the existence and effectiveness of climate change adaptation practices. This knowledge can orient policy and foster ongoing adaptation towards resilience.

Furthermore, small-scale agriculture faces constraints that limit its effectiveness in combating poverty and food insecurity attributed to climate change. This is coupled with poor soil fertility, poor farming practices, and increased urbanization, leading to the urgent need to optimize adaptation and build resilience in the sector as well as bridge the production gap (Muthuwatta *et al.*, 2018; Abegunde *et al.*, 2019). While efforts to reduce anthropogenic causes of climate change are necessary, the focus also needs to be on the sustainable use of available factors of production. This includes promoting equitable use of water resources and breeding for drought and frost-tolerant varieties, especially for Arid and Semi-Arid Lands and coastal cities, which have received considerable attention (Aguiar & Waldfoegel, 2018).

More importantly, Altieri & Nicholls (2017) and Nunn *et al.* (2021) argued that fostering effective adaptation to climate change will require the involvement of multiple stakeholders since different regions have been impacted differently. Therefore, situation-specific measures are desirable to build resilience in the agriculture sector, particularly in promoting the adaptive capacity of smallholder farmers. On the other hand, Muthuwatta *et al.* (2018) emphasized the need to consider strategies that can lead to proactive adaptation to minimize the projected risks of climate change and ensure that small-scale farmers and vulnerable communities can recover and build resilience in different sectors. Despite the importance of keeping climate adaptation content specific, only a few studies have reported success (Fahad & Wang, 2018; Gowda *et al.*, 2018; Gaisie & Cobbinah, 2023).

In a recent study by Wolf *et al.* (2022) on transformative adaptation as a sustainable response to climate change, developed and developing economies have laid down strategies for building transformative adaptation to climate change. Additionally, Robinson (2020) reported that other economies have focused on identifying factors that influence the adoption of laid adaptation practices and thus have outlined key means of how policies can support adaptation at different levels. These include facilitating access to credit, information, inputs, and extension services, among other measures. The United Nations Framework Convention on Climate Change (2022) extensively assessed climate-related vulnerabilities along with non-climate-related vulnerabilities, examining the array of adaptation measures implemented. In response,

recommendations have surfaced, emphasizing the need for developing nations to craft adaptation strategies. In parallel, developed countries are urged to extend essential financial and technological aid to bolster these adaptation endeavors (Berrang-Ford *et al.*, 2019). This collaborative approach is pivotal in addressing the complexities of climate change on a global scale.

Empirical research on climate change adaptation in Sub-Saharan Africa has shown that farmers are adopting various farm-level responses, including change in crop and livestock management practices, land use, and farm management strategies such as tree planting, irrigation, water harvesting, soil and water conservation measures, tillage practices, and soil fertility management (Kamali *et al.*, 2022; Amaranto *et al.*, 2022). However, the ability of farmers to implement these practices depends on their level of adaptiveness. For example, communities with limited resources may find adopting certain climate adaptation practices challenging despite having information on them. Additionally, national adaptation policies may impact farmers' ability to adopt adaptation practices by regulating access to information, credit, and extension services (Thinda *et al.*, 2020).

Giusto *et al.* (2018) highlights the necessity for increased research concerning policy integration across various African governments. Specifically, they emphasize the importance of integrating climate research into policy frameworks, budget allocations, and practical implementation, particularly in Sub-Saharan Africa. An example is seen in Zambia, where efforts are underway to develop policies aimed at enhancing farmers' capabilities for climate adaptation through climate-smart agriculture, aiming to establish sustainability and resilience for both present and future generations. This suggests that evaluating adaptive capacity becomes crucial to gather pertinent information and identify potential opportunities for localized and individualized adaptation interventions (Pardoe *et al.*, 2018).

On the other hand, Kenya has sought interventions for building the adaptive capacity and resilience to climate change through policy frameworks such as the National Climate Change Response Strategy (NCCRS) and National Climate Change Action Plan (NCCAP) (Chepkoech *et al.*, 2020). Kenya benefits from projects being

implemented within the East Africa region and Africa. Some of these include the Climate Change Adaptation Action (CCAA) program, which finances multi-country projects that are focused on water governance, awareness-raising among parliamentarians, creating an adaptation policy space, integrating indigenous knowledge into climate risk management, and other reviews of Current and Planned Adaptation Action (Kiremu *et al.*, 2022). Moreover, there have been attempts to assess the rate of adaptation in Kenya by examining farmers' practices to adapt to trending climate impacts. Despite the potential contribution of adaptation practices to farm efficiency, sustainability, and productivity, their adoption still needs to grow, especially among smallholder farmers (Bedeke, 2023).

Overall, the gaps identified in the existing literature on climate adaptation include a pressing need to enhance the effectiveness of adaptation strategies to substantially reduce the already felt impacts of climate change. Understanding farmers' awareness and perceptions regarding the existence and effectiveness of climate change adaptation practices remains a critical area that demands further exploration. Furthermore, it is imperative that constraints routinely encountered by smallholders, including degraded soil quality, traditional cultivation techniques, and the encroachment of urban areas, be comprehensively remediated to fully maximize the potential of adaptation initiatives. Furthermore, while the previous studies focused on the adoption of adaptation practices, there is a lack of emphasis on proactive adaptation strategies to minimize projected climate change risks for vulnerable communities (Ali, 2021; Atinafu *et al.*, 2022). Lastly, the integration of adaptation policies and the assessment of adaptive capacity for effective local and individual adaptation interventions require more attention in the literature.

2.2 Awareness of Climate Change Impacts and Adoption of Adaptation Practices

For communities to effectively respond and adapt to the impacts of climate change, they must have a clear understanding of these effects and the need for necessary adjustments. However, there needs to be more awareness levels regarding climate change impacts between developing and developed countries. This difference could be attributed to the limited public efforts in developing countries to create awareness and disseminate information about climate change (Agesa *et al.*, 2019; Patel *et al.*, 2020).

Farmers' perception aligns with the climatic data, indicating the importance of risk awareness, perception, and adaptive capacity in proper adaptation (Ado *et al.*, 2019). Although various studies have focused on the impacts of climate change, it remains to be seen whether farmers can perceive and adapt to the changes (Williams *et al.*, 2020). Nonetheless, research suggested a strong relationship between farmers' awareness of climate change impacts and their mitigation strategies (Giusto *et al.*, 2018).

A study by Negera *et al.* (2022) in Ethiopia reported that most farmers were aware of climate change but needed more specific knowledge about its impacts on agriculture. The study further revealed that education, extension services, and access to information influenced farmers' awareness, thus suggested that effective extension services and awareness campaigns could increase farmers' understanding of climate change impacts. In contrast, a study by Okaka and Odhiambo (2018) in Kenya found that farmers were highly aware of climate change and its potential impacts on agriculture. This awareness was influenced by their experience of extreme weather events and their perceptions of climate change as a personal and societal issue.

The perception of climate change impacts among farmers plays a pivotal role in determining their response towards adopting climate change adaptation practices (Bedeke, 2023). Failure to acknowledge these impacts can lead to maladaptation or limited adaptation efforts, emphasizing the importance of delving deeper into how farmers' awareness influences their adoption of adaptation practices. Previous studies have not extensively addressed this aspect, highlighting the critical need for a comprehensive understanding (Abbasi & Nawaz, 2020; Galadima *et al.*, 2020). Therefore, assessing farmers' awareness levels and local exposure becomes crucial in designing adaptation practices tailored to specific contexts (Ferreira *et al.*, 2022). However, there remains a significant gap in understanding how awareness and perception directly influence the adoption of adaptation practices. Additionally, farmers might require assistance in distinguishing between the perceived impacts of climate change and the observable local environmental degradation trends (Kovaleva *et al.*, 2022).

2.3 Extension Dissemination Channels and Adoption of Climate Change Adaptation

The need to advance agricultural productivity by enhanced technology transfer and adoption revolves around the ability of extension to reach their clientele within the stipulated time. In a study by Abukari *et al.* (2020), the choice of extension delivery channels depends on the knowledge and capacity of the extension officer, the information to be delivered, and the availability of resources. The delivery channels can either be disseminative or communicative based on the dimension of information flow. Further, the delivery channels can be classified as community-based, print-based, mass-media, and Information Communication Technology (ICT) (Olagunju *et al.*, 2021).

Several researchers have investigated the efficacy of dissemination channels in promoting the adoption of proven agricultural practices and technologies (Abukari *et al.*, 2021; Carroll *et al.*, 2022). Commonly used extension channels encompass radio, television, print media, farmer-to-farmer contacts, and extension visits. However, effectiveness of these methods relies on the characteristics of the target audience and the skills of the extension personnel being each channel presents distinct advantages (Ishida *et al.*, 2018). For instance, radio channels serve as efficient platforms for swiftly disseminating agricultural technologies and practices to a broad audience at relatively low costs. Additionally, radios can effectively raise awareness and maintain farmers' interests. However, enhancing its effectiveness often involves complementing it with other training methods (Suleiman *et al.*, 2021).

It is presumed that the adoption of agricultural technologies begins with awareness. Extension services aim to promote awareness of climate impacts, intending to facilitate the adoption of climate adaptation technologies (Ado *et al.*, 2019). Despite minimal or no adaptation, efforts have been made by the extensionists to disseminate climate adaptation strategies to farmers (Adolwa *et al.*, 2018). However, instances of underutilization of these technologies and low exploitation of emerging interventions have been observed (Seddon *et al.*, 2020). Addressing the need to promote climate adaptation among smallholder farmers involves tackling the causes behind the low adoption of climate change adaptation strategies. Consequently, it becomes necessary to analyze the effectiveness of various dissemination channels in empowering farmers

by delivering climate adaptation information. However, previous studies have overlooked conducting an in-depth investigation into the specific communication channels preferred by both farmers and extension staff when disseminating information specifically related to climate change impacts, mitigation, and adaptation (Ragasa, 2020; Iqbal *et al.*, 2021; Suleiman *et al.*, 2021).

Moreover, Adolwa *et al.* (2018) emphasized the necessity for more insights into the communication channels preferred by both farmers and extension staff regarding information dissemination on climate change impacts, mitigation, and adaptation. The lack of such information has resulted in low adoption rates among farmers, indicating a pressing need for more effective communication and collaboration between researchers and agricultural communities (Iqbal *et al.*, 2021). In response, the present study aimed to fill this gap by investigating and evaluating the effectiveness of individual, group, and mass media channels in communicating climate change adaptation strategies. This investigation holds significant importance in enhancing resilience within the agricultural community.

2.4 Extension Approaches and Climate Change Adaptation

An extension program aims to provide education and knowledge transfer regarding new agricultural technology, which is crucial in addressing concerns about agricultural productivity (Dayamba *et al.*, 2018). According to Mustapha *et al.* (2017), agricultural extension involves a series of communicative interventions that help resolve problematic situations and play a significant role in climate change adaptation. The significance of extension in responding to climate change has been debated in various workshops, particularly in developing countries that require urgent climate action. In Latin America, workshop participants have noted that climate information is either unavailable or insufficient, making it challenging to use for modeling and scenario development (Filho *et al.*, 2018). However, these discussions did not specifically address the effective integration of extension approaches in facilitating climate change adaptation strategies, leaving a gap in the practical application of extension programs for addressing climate-related challenges.

Suleiman *et al.* (2021) argued that efforts to communicate climate-related information have mainly focused on highlighting the threats of climate change rather than promoting an understanding of possible adaptation challenges and raising awareness of adaptation pathways for behavioral change. This approach has resulted in a gap between awareness and adaptation, necessitating interventions to involve farmers in activities to mitigate the soaring impacts of climate change (Antwi-Agyei & Stringer, 2021). While various studies have documented the efforts of smallholder farmers to adapt to climate change, they need more access to timely and accurate information (Altieri & Nicholls, 2017; Ado *et al.*, 2019). Limited extension services for smallholder farmers have hampered the flow of information from research centers, with the risk of some of the information needing to be updated before adoption despite the statements in research. Furthermore, past efforts to communicate climate information to vulnerable rural communities have typically employed one-way dissemination approaches (Adolwa *et al.*, 2018; Albright *et al.*, 2020; Eta *et al.*, 2022). These studies highlighted the existing information gap and lack of bidirectional communication channels that could enable effective integration of climate information into extension services, hindering comprehensive adaptation efforts by farmers.

There has been a shift to greater dialogue and insights among stakeholders on promoting extension systems in rural areas. Studies in Africa and Asia reported six primary channels used to disseminate climate change information (Yekinni & Afolabi, 2019; Abukari *et al.*, 2021). These include radio, television, online platforms, printed media, public demonstrations, and community barazas. Furthermore, according to Filho *et al.* (2018), much needs to be done regarding assessments of other variables related to communication that drive change of farmer behavior, including the type of information disseminated, the target audience, and the dissemination approach. This prompts more research to investigate the approaches applied and their relevance in promoting adaptation.

Extension policies and strategies are necessary for the agricultural sector to adapt to climate change (Mustapha *et al.*, 2017). Farmers' exposure to extension approaches and activities influences their adaptation as it promotes the dissemination of agricultural technologies. Additionally, Ado *et al.* (2019) reported that agricultural extension

approaches enhance the effectiveness of adaptation decisions and the applicability of the adaptation practices; therefore, it should be emphasized. However, there needs to be more information on best extension practices and context-specific approaches (Olagunju *et al.*, 2021). These studies emphasized the importance of extension services in adaptation but did not comprehensively address the gaps in understanding the best practices and locally relevant approaches that would maximize the efficacy of extension services in the context of climate change adaptation.

2.5 Effectiveness of Project-Based Extension Approach

The project-based extension approach has been widely used in promoting climate change adaptation practices in various parts of the world. However, more empirical evidence is needed to illustrate its effectiveness in Kenya. Moreover, implementing a project-based approach requires more funding and resources to achieve rural development goals (Park *et al.*, 2018). According to the literature, the project-based approach effectively promotes the dissemination of agricultural technologies as it provides a hands-on learning experience, encourages community participation, and promotes sustainable development (Ado *et al.*, 2019). A study conducted by Morón & Calvo (2018) in South Korea found that a project-based approach was reliable in disseminating climate change adaptation practices, such as water management and disaster preparedness, among farmers. Similarly, a study conducted by Zikargae *et al.* (2022) in Ethiopia found that a project-based approach effectively promoted climate change adaptation practices, such as crop diversification and soil conservation, among smallholder farmers.

Using a project-based approach has shown positive outcomes compared to conventional extension approaches. One study by Otieno *et al.* (2021) reported that farmers who participated in the One Acre Fund project had higher maize yields than those who received information through conventional approaches. Similarly, Schipper *et al.* (2017) reported that a project-based approach effectively promoted rainwater harvesting and conservation agriculture among smallholder farmers in Kisumu County. Another study in Siaya County showed that a project-based approach successfully promoted climate change adaptation practices like agroforestry and soil and water conservation among smallholder farmers (Nyberg, 2020). However, the effectiveness

of the project-based approach in fostering climate change adaptation needs to be further examined among different groups (Dayamba *et al.*, 2018).

Previous studies primarily focused on the effectiveness of the project-based extension approach in promoting climate change adaptation practices among smallholder farmers in specific regions (Bernard *et al.*, 2019; Ragasa, 2020). While this approach promises potential benefits, uncertainties persist regarding its ramifications for agricultural populations overall, especially as socioeconomic and local environmental factors can diverge so markedly. Additionally, previous studies often lacked a comprehensive evaluation of the long-term sustainability and scalability of the project-based approach beyond immediate agricultural outcomes (Morón & Calvo, 2018; Otieno *et al.*, 2021). The current study aims to address these gaps by assessing the broader effectiveness, scalability, and sustainability of the project-based extension approach in fostering climate change adaptation practices across diverse socio-economic groups and geographical regions within Kenya.

2.6 Adoption of Climate Adaptation Practices

The impacts of climate change on agriculture have been documented in scientific literature, particularly in Sub-Saharan Africa, where agriculture is a crucial source of livelihood and food security (Omer & Hassen, 2020; Kimengsi *et al.*, 2022). To counter the negative effects of climate change on smallholder farmers, interventions need to be developed to make life bearable, reduce yield losses, and boost overall net revenue (Davidson *et al.*, 2019). Therefore, there is a need to design modern adaptation policies, with particular attention given to adopting technological innovations in the agricultural sector, including crop management, livestock management, land and water conservation, and off-farm adjustment programs. Developing countries have implemented strategies to promote adopting sustainable practices that can build resilience in the agricultural sector and help households mitigate food insecurity (Williams *et al.*, 2020). However, previous studies have overlooked the nuances of the perception of climate change among households, geographic influences, social and cultural contexts, economic endowments, and the agricultural policy's impact on adaptation choices.

According to Sahu (2022), India has released a designed National Action Plan on Climate Change (NAPCC), which comprehensively aims to take actions for mitigation and adaptation to climate change impacts. The plan highlighted the strategies aimed primarily at the urban regions to reduce the vulnerability and risks of climate change. Even though the strategies to maintain green bases are strategized, implementation and adoption of the adaptation strategies still need to be improved. Moreover, in their study, Bhatnagar and Sharma (2021) observed that India, like any other developing country, has a huge dependence on climate-sensitive sectors, making adaptation even more challenging. Similarly, Shikuku *et al.* (2017) reported that East African countries continue to experience similar adoption constraints, including financial, institutional, and knowledge gaps associated with the uncertainty of climate change impacts.

The need to protect the agricultural sector in Africa has led to the implementing of Climate Smart Agriculture (CSA) as one of the interventions. The CSA approach focuses on the three main pillars of food security, adaptation, and mitigation. Several African studies have documented the adoption of selected climate-smart practices and success stories in Sub-Saharan Africa, Nigeria, South Africa, and Kenya (Makate *et al.*, 2019; Paul *et al.*, 2020; Barasa *et al.*, 2021). In Kenya, various government and other stakeholders' adaptation strategies have been implemented to mitigate the impacts of climate change (Mulwa & Kabubo-Mariara, 2022). Some strategies range from using climate-resilient crop varieties released from the research institutes (KALRO) to crop diversification (Kiremu *et al.*, 2022). This is governed by the fact that national policies regarding climate adaptation lie wholly on every economy's enabling environment and financial capacity. However, Bedeke (2023) reported that the choice of adaptation measures could depend on households' perception of Climate Change, the geographic location, social and cultural concepts, economic endowment, and the agricultural policy of a country. Moreover, the differences in farmers' abilities and adaptation costs of implementing different practices are necessary for ranking adaptation strategies in feasibility (Shikuku *et al.*, 2017). Previous studies failed to deeply analyze the reasons behind the disparities in farmers' abilities and adaptation costs, thus neglecting to provide a comprehensive feasibility ranking of different adaptation strategies (Davidson *et al.*, 2019; Bhatnagar & Sharma, 2021).

In addition, smallholder farmers have also practiced climate-smart agriculture, which applies mixed cropping, zero tillage, mulching, intercropping, crop rotation, integrated crop-livestock management, agroforestry, and improved water management (Bhatnagar & Sharma 2021). These aim to promote agricultural sustainability, productivity, and adaptation, enhancing national food security. Recent research on adopting soil fertility management methods among smallholder farmers in the central highlands of Kenya pointed out that resource abundance is a critical factor influencing climate adaptation (Autio *et al.*, 2021). Moreover, a study on fertilizer application and improved maize varieties in Kiambu, Embu, and coastal lowlands reported low adoption rates due to climatic conditions, input and labor costs, and limited access to extension services (Gichimu *et al.*, 2020). Therefore, a better understanding of how they do this is essential to designing incentives to improve adaptation. However, the previous studies failed to thoroughly investigate the factors influencing low adoption rates of specific climate adaptation practices, such as climatic conditions, input and labor costs, and limited access to extension services, thereby impeding the development of effective incentivization strategies for improved adaptation (Pardoe *et al.*, 2018; Nunn *et al.*, 2021).

2.7 Theoretical Framework

The study was guided by the Diffusion of Innovations Theory by Everett Rogers in 1962, which explains how new ideas and technologies spread through a social system. The theory focuses on how diffusion and adoption of innovations are influenced by factors such as the characteristics of the innovation, the communication channels, and the social system in which the innovation is introduced (Rogers *et al.*, 2014). Innovation adoption occurs in five stages: knowledge, persuasion, decision, implementation, and confirmation. The available resources, socioeconomic status, and the principles in each social system influence how people value a given innovation (Pullaila *et al.*, 2018). Thus, it forms the basis for categorizing adopters as either innovators, early adopters, early majority, late majority, or laggards.

Five key attributes of a good technology influence the adoption rate, including relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). However, how an individual views varied innovation attributes influences the adoption

rate, even though the most appropriate adoption occurs through training and peer learning within a given social setup. The theory focuses on the farmers' decision-making process to adopt or reject a technology, particularly the micro-perspective of behavioral change; this defines the study's objective to determine the effectiveness of extension in promoting the adoption of climate change adaptation practices among smallholder farmers (Wolf *et al.*, 2022).

While previous research has largely concentrated on analyzing farmers' differences in adopting or rejecting innovations, there is need for equal emphasis on studying the characteristics of these innovations (Mlenga & Maseko, 2015). Innovation diffusion occurs within social systems influenced by the socioeconomic status of adopters, where extension services play a pivotal role in enhancing technology diffusion (Sahin, 2006). Furthermore, Arslan *et al.* (2013) highlight that some farmers adopt technologies to receive subsidies, while others do so due to their engagement with extension services, fostering innovation diffusion. Consequently, this theory serves as a framework to examine the delivery of extension services for disseminating information on climate adaptation. It aims to unravel the relationship between the awareness level of climate change impacts, extension delivery channels, and the efficacy of project-based approaches in bolstering the adoption of climate change adaptation practices among smallholder farmers in the Nyatike Sub-county.

2.8 Conceptual Framework

This research had hypothesized that the rate of adoption of climate change adaptation practices in Nyatike Sub-county was dependent on the effectiveness of extension approaches specifically project-based that has been majorly adopted by private and public extension. The level of adoption also depended on the effectiveness of the extension channels utilized to share information on the impact of climate change and possible adaptation practices.

The independent variables consisted of the farmers' awareness of climate change impacts, extension dissemination channels, and the use of a project-based approach, while the outcome variable was the adoption of climate change adaptation practices. The extent to which farmers would adopt climate change adaptation practices could

depend on their awareness levels of the effects of climate change. Farmers who were highly aware of the negative impacts, such as floods, were likelier to adopt the adaptation practices than those who did not encounter climate change risks and hazards. Therefore, the study intended to determine the relationship between the variables, as shown in Figure 1.

Secondly, the effectiveness of extension services in promoting, adopting, and sustaining climate adaptation practices could be determined by the approaches and methods employed to reach farmers with timely and relevant information. For example, the role of radio in providing farmers with prompt information about the impact of climate change affects the reception and adoption of new adaptation technologies. The efficiency and adequacy of the approach in communicating these adaptation practices are also crucial in promoting their adoption. The county extension department has been using the project-based extension approach to promote climate change adaptation by implementing various projects to train farmers on appropriate adaptation practices. The study aimed to determine how effective the approach is in enhancing regional adaptation.

The intervening factors presumably affected the dependent variable, but they were not investigated. For instance, the growing population of farmers influences the ratio of extension agents to farmers limiting number of contacts thus a broader dissemination network reducing the pace for information delivery. On the other hand, government policies and regulations intervene by shaping extension services' focus on climate adaptation in terms of funding, subsidies, framework, and other regulatory measures. These in turn influenced the relationship between the explanatory and the outcome variable.

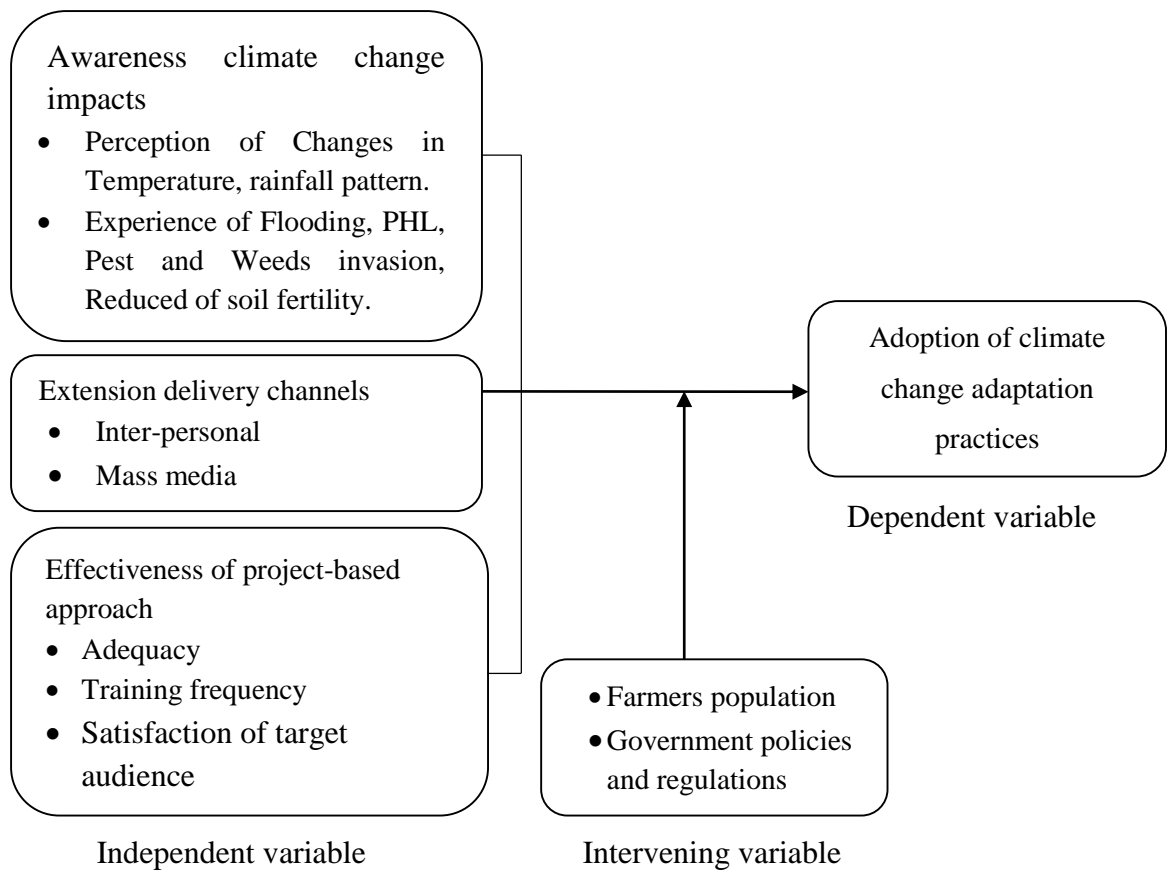


Figure 1: Conceptual Framework
(Authors' Conceptualization)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Location of the Study

The study was conducted in the Nyatike sub-county, geographically located in Migori County, Southwestern part of Kenya (Appendix III). It is located between longitudes 34:0⁰E and 34.4⁰ E and latitudes 1.0⁰S to 1.0⁰S. According to the latest report by the Kenya National Bureau of Statistics, the sub-county covers approximately 675.70 square kilometers and a 176,162 human population (KNBS, 2019). The population distribution is influenced by the increasing number of gold mining activities within the seven wards (Onyango, 2021).

Nyatike is a sub-county situated on the banks of Lake Victoria. Its soil composition consists of sandy loams and dark clay, which result from sedimentation and deposits brought by floods from upland regions. The area has an altitude of 1,140 meters above sea level. On average, it receives an annual rainfall of between 700 and 1800 millimeters, and temperatures typically vary between 15⁰C and 27⁰C. The climate is influenced by its inland equatorial location, as well as its altitude, relief, and the presence of Lake Victoria. Rainfall is continuous throughout the year, with minimal distinction between the two rainy seasons (Migori County Government, 2020).

The sub-county experiences unpredictable weather patterns, including recurring floods, short annual rains, and warm local winds from Lake Victoria. These unpredictable weather patterns have detrimental effects on agriculture and livestock production, leading to an increased risk of food insecurity and rising poverty levels (Ojuok, 2020). The sub-county's agricultural system is characterized by small-scale farming and livestock production, which are extensively managed. The primary crops grown in the area are maize, sorghum, cassava, and sweet potatoes. Fishing and small-scale gold mining are other significant economic activities in the Nyatike sub-county (Migori County Government, 2020).

3.2 Research Design

The study employed a descriptive survey design to examine the relationship between multiple variables. This design is particularly useful when the researcher has no control

over independent variables that might influence the dependent variable (Seeram, 2019). The research collected data from a chosen sample without any form of manipulation. Specifically, the study aimed to investigate the relationship between farmers' awareness, extension dissemination channels, the effectiveness of extension approaches as the independent variables and the adoption of climate adaptation practices as the dependent variable.

3.3 Target Population

The target population consisted of 26,354 smallholder crop farmers residing in Nyatike Sub-county. The sub-county has seven wards including North Kadem, Macalder, Kaler, Kachieng, Kanyasa, Got Kachola, and Muhuru, as indicated in Table 1. In this study, the sample was drawn from smallholder crop famers in the seven wards that served as a sampling frame from which a representative sample was selected.

3.4 Sampling Procedure and Sample Size

3.4.1 Sample Size Determination

The appropriate sample size for this study was determined using Slovin's (1960) sample size determination formula. The sample was computed as;

$$n = \frac{N}{1+N(e)^2} \dots\dots\dots(i)$$

Where;

n = is the sample size

N = is the population size

e = the level of significance

$$n = \frac{26,354}{1 + 26,354(0.05)^2} = 395$$

Therefore, the study sample was 395. The sample size was distributed as shown in Table 1.

3.4.2 Sampling Procedure

The research employed a cluster sampling procedure to ensure the selection of a representative sample from the intended population. Therefore, the target population in

Nyatike Sub- County was similarly organized into clusters, with a total of seven distinct divisions corresponding to the respective wards. To achieve a representative sample from each cluster, participants were chosen randomly from each ward, ensuring proportional representation across the population.

Table 1: The Sample Size per Ward

Ward	Population	Sample Size
Macalder	4112	62
Kaler	3323	50
Kachieng	3816	57
Kanyasa	3252	49
Got Kachola	4030	60
Muhuru	3241	49
North Kadem	4580	68
Total	26,354	395

Source: Agriculture Department, Nyatike sub-county (2021)

3.5 Research Instrument

To collect information on the variables, a semi-structured questionnaire was utilized. The questionnaire was divided into four sections for ease of use and comprehensibility. Section A covered the demographic characteristics of the respondents (age, gender, land ownership, and educational background). Section B captured the respondents' awareness of climate change impacts. Section C sought to gather information on the effectiveness of extension channels and methods. Lastly, Section D centered on the effectiveness of project extension approach and the last section answered questions on extent of adoption of climate adaptation strategies.

3.6 Pilot Study

A pilot study involves small-scale testing of the research methods and data collection procedures for the main study. An average of 10-20% of the sample size is adequate for a pilot study (Hertzog, 2008). In this study, the questionnaire was administered to 10% of the sample size, giving 40 respondents. The pilot study was conducted in Suba South where farmers possessed characteristics comparable to those in the study area with matching agroecological conditions. The pilot study aided in improving the quality of the instrument by identifying errors in the items. Data from the pilot study was also used to estimate the instrument's reliability.

3.6.1 Validity of the Research Instrument

A research instrument is considered valid when it measures what it is intended for and gives relevant information (Wong & Yamat, 2020). This study emphasized face validity, which measures the tool's surface value, and content validity, which measures its ability to gather information about the variables. This was done to ensure that the tool is appropriate for measuring the study's outcomes in terms of context and objectives, as well as psychometric aspects. To check the validity of the questionnaire, supervisors, experts and peers were engaged. Any necessary corrections were made to ensure validity of the tool.

3.6.2 Reliability of the Instrument

A research tool is reliable if it can be used multiple times within different time frames to produce consistent results. Cronbach's Alpha measures internal consistency within different acceptable ranges in various research fields. According to Taber (2018), a minimum of 0.60 Alpha value is acceptable for social sciences. Therefore, in this study, an alpha value of between 0.61-0.81 was obtained for all variables as shown in Table 2. Hence, the instrument was internally consistent.

Table 2: Reliability Coefficients

Variable	No. of Items	Cronbach's Alpha
Awareness levels ^a	7	0.71
Extension channels ^b		
Interpersonal channels	3	0.61
Mass media	4	0.64
Project-based approach ^c	5	0.71
Adoption of adaptation practices ^d	8	0.81

Note. ^{a, b, c} = Independent variable, ^d = Dependent variable

3.7 Data Collection Procedures

Data was collected using a pre-tested semi-structured questionnaire addressing the variables under study (Appendix II). An inception meeting was held with relevant authorities, including the area chief and the Sub- County extension staff. Eligible participants obtained through random sampling within each stratum were informed of the research intention. This ensured that there was room to consent to participate freely. The questionnaire was administered to the respondents in their homes while others were in their farms especially during morning hours. The research questionnaire was

digitized in an Open Data Kit (ODK), and the respondents were given access to the digitized form to fill out and submit. This ensured efficiency and faster submission of the filled forms. For the sake of respondents with no formal education, the researcher translated the questions into the local language to obtain relevant responses and promote accurate data collection.

3.8 Data Analysis

Collected data was analyzed using SPSS Version-25. Various statistical techniques were utilized to explore relationships and patterns in the collected data. Firstly, the variables were measured on a 5-point Likert scale (Table four, summary of analysis).

3.8.1 Research Question One

To determine the influence of the level of awareness of climate change impacts on the adoption of climate adaptation practices, descriptive statistics and analysis of variance were utilized. The independent variable was categorical in nature with three levels awareness of undecided, aware, and highly aware of climate change impact while the dependent was continuous from the computed scores on adoption of climate change adaptation practices. Before running the test, the assumptions of normality were checked using kurtosis and skewness, while homogeneity of variance was tested using Levene's test ($p=0.65$).

3.8.2 Research Question Two

The study employed ordinal logistic regression analysis to determine the relationship between access to information through different extension delivery channels and the adoption of climate change adaptation practices. The extension channels considered included interpersonal communication methods, such as farmer-to-farmer interactions, public gatherings, and extension visits, as well as mass media channels, such as radio, television, and print media. This approach was used to assess how these communication channels influenced the likelihood of farmers adopting various adaptation practices.

3.8.1.1 Multicollinearity

Multicollinearity occurs when independent variables in a regression model are highly correlated, which can lead to unstable coefficient estimates. In the Table 3 shows the

results of checking multicollinearity using tolerance values and variance inflation factors (VIFs).

Table 3: Multicollinearity Statistics

Variable (Constant)	Collinearity Statistics	
	Tolerance	VIF
Level of awareness	0.901	1.100
Interpersonal channels	0.907	1.103
Mass media channels	0.907	1.103

a. Dependent Variable: Adoption of Adaptation Practices

The VIF was 1.100, and a tolerance of 0.901. According to Miles (2014), a VIF less than 10 and tolerance close to 1 suggest that the assumption of no perfect multicollinearity is met. The VIF for Interpersonal Channels was 1.103, and a tolerance of 0.907. The VIF for Mass Media Channels was also 1.103, and the tolerance is 0.907. Similarly, for Mass Media Channels, the VIF is less than 10 and tolerance is close to 1, indicating that the assumption of no perfect multicollinearity is met. In this study, the multicollinearity assumption is satisfied for the independent variable.

3.8.1.2 Proportional Odds Assumption

This occurs when the relationship between the independent variables and the log odds of the dependent variable falling into a higher category remains consistent across all outcome categories. This assumption was met at $p > 0.05$. This suggested that the assumption of proportional odds holds, meaning that the relationship between the independent variables and the log odds of the outcome being in a higher category is consistent across all outcome categories.

3.8.3 Research Question Three

Spearman's rank correlation analysis was used to determine if the use of project-based extension approach correlates with the adoption of climate change adaptation practices. The use of project-based extension approach was measured using scores computed from Likert-type items.

Table 4: Data Analysis Matrix

Research Question	Independent Variables	Dependent Variable	Statistics
Does awareness level of climate change impact, influence farmers' adoption of climate adaptation practices?	Awareness levels of climate change impacts	Adoption of climate adaptation practices	Descriptive statistics: Median, frequencies, percentages. Inferential statistics: Analysis of Variance
What is the relationship between the extension delivery channels and the adoption of climate change adaptation practices?	Selected extension delivery channels	Adoption of climate adaptation practices	Descriptive statistics: Median, frequencies, percentages, chi-square. Inferential statistics: Ordinal Logistic Regression
What is the association between the use of a project-based extension approach and adoption of climate change adaptation practices?	Use of project-based	Adoption of climate adaptation practices	Descriptive statistics: Median, frequencies, percentages. Inferential statistics: Spearman rank Correlation

3.9 Ethical Considerations

The study adhered to ethical standards in both its planning and execution. The researcher obtained official approval from the Chuka University Ethical Review Committee and NACOSTI before commencing the study. To gain access to the study participants, appropriate permission had to be obtained from the area administration. The study's purpose was explicitly stated to the respondents, emphasizing that the data collected would be used solely for academic purposes to promote transparency. A consent form was used to obtain the respondents' consent and assure their safety throughout the research period. Further, respondents were informed that participation in the study was voluntary, and anonymity was maintained since the study would not gather any identifiers.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Questionnaire Return Rate

Ensuring an acceptable survey response rate is critical in avoiding sampling bias since it limits the generalizability of the findings thus threatening the external validity. Data was collected from a sample of 395 farmers from the seven wards in Nyatike Sub-County.

Table 5: Questionnaire Return Rate by Ward (N = 395)

Ward	Freq. (<i>f</i>)	Percent (%)
Got Kachola	60	15.18
Kachieng	57	14.43
Kaler	50	12.65
Macalder	63	15.69
Kanyasa	49	12.41
Muhuru	49	12.41
North-Kadem	68	17.21
Total	395	100.00

As presented in Table 5, all the three hundred and ninety-five questionnaires that were distributed to the respondents were completed and collected representing a 100% return rate. This remarkable return rate was attained due to the assistance and the cooperation of the local leaders as well as the target farmers, and the in-person questionnaire administration. The use of Online Data Kit, the simplicity and length of the instrument also facilitated efficiency which contributed to the high return rate. This confirms the findings of Holtom, *et al.* (2022) that the length and complexity of the instrument can lead to fatigue which compromises the response rate. The high response rate improved the quality of the research data and allowed the generalizability of the findings to the whole population. Additionally, the return rate was higher than the 90% that Johnson & Morgan (2016) recommended for data analysis, discussion, and conclusion.

4.2 Respondents' Demographic Characteristics

The study examined the characteristics of various study participants, shedding light on the number and types of individuals involved in the study. This information helped clarify the target population to which the study findings were applicable, as well as the generalizability of the results to similar contexts. Moreover, providing a comprehensive

description of participant characteristics enables easier replication of the research in future studies. The characteristics studied included age, gender, education level, farm acreage, duration of stay within the study area, and the experience of the farmer.

4.2.1 Age of the Respondents

Description of the respondents age involved an analysis of the frequencies, percentages, range, mean, and standard deviation. Table 6 shows the distribution of research subjects based on their ages.

Table 6: Distribution of Research Participants by Age (N = 395)

Age (Years)	Frequency (<i>f</i>)	Percent (%)
18-35	80	20.25
35-60	215	54.44
Above 60	100	25.32

Note. $M = 48.76$; $SD = 14.47$

The mean age of the overall group was 48.90 years ($SD = 14.47$) which falls within the economically and productive age range. Specifically, the average age for females was 49.11 years, whereas the average age for males was slightly lower at 48.76 years. This implies that most of the farmers in Nyatike sub-county were middle-aged. Therefore, they had the right experiences needed for decision making relating to the adoption of climate adaptation practices. These findings are in line with those of Thinda *et al.* (2020) who observed that many of the farmers in south Africa were middle-aged and were more likely to adopt adaptation practices due to their innovativeness and willingness to try new technologies.

The high standard deviation ($SD = 14.47$) indicated significant variability in the ages of the farmers, despite a considerable portion falling within the 35 to 60-year age bracket ($n = 215$, 54.44%). Moreover, a few of respondents were over 60 years old ($n = 100$, 25.32%), suggesting that approximately a quarter of the farmers in the sub-county were elderly. The research also revealed that the participation of young farmers was relatively limited ($n = 80$, 20.25%). This might have resulted from the fact that the study targeted household heads involved in farm decision making. It also suggests that there was limited involvement of youths in agricultural activities within the sub-county although research has shown that young farmers can be more productive and could be

interested in exploring and adopting new farming innovations including climate adaptation practices (Musafiri *et al.*, 2022). Additionally, Ali and Erenstein (2017) reported a negative significant association between age and adoption of climate adaptation practices. Which implied that as farmers advance in age adoption of new technologies goes down.

4.2.2 Gender of the Respondents

The study sought to understand the gender distribution of the research participants in the survey. The information was summarized using frequencies and percentages and the results are presented in Table 7.

Table 7: Distribution of Research Participants by Gender (N = 395)

Gender	Frequency (f)	Percent (%)
Female	140	35.44
Male	255	64.56

The results in Table 7 show that majority of the respondents ($n= 255$, 64.56%) were male, while 140 individuals (35.44%) were female. This implies that more males were involved in farming compared to females within Nyatike sub-county. Additionally, it can also be taken to mean majority of the households were headed by men. This finding is in line with Sennuga *et al.* (2020) who reported that farming is predominated by male as they own the right to farming decisions. Based on the culture of the Luo people who are the main inhabitants in the sub-county, men are regarded as the head of the household. Women only assumed household headship in specific situations, such as being widows or when husbands were absent due to work-related reasons. Although, men were at the centre of farm decision making, many of the agricultural activities were undertaken by women. This confirmed Gebre *et al.* (2019) conclusion that maize production was predominantly carried out by females.

Additionally, gender has been found to have an impact on the adoption of adaptation practices, particularly in situations where one gender is more involved in a specific enterprise than the other, as reported by Adzawla *et al.* (2019). The study highlighted that male-headed households were more inclined to adopt adaptation strategies and had a higher adaptive capacity compared to female-headed households.

4.2.3 Education Level of the Respondents

To understand the level of education attainment of the study participants' preliminary analysis were done using frequencies and percentages. Table 8 presents the distribution of respondents based on the education categories.

Table 8: Distribution of Respondents by the Educational Levels (N = 395)

Education level	Frequency (<i>f</i>)	Percent (%)
None	19	4.81
Primary	129	32.66
Secondary	157	39.75
Tertiary	90	22.78

According to the survey results in Table 8, a significant proportion of respondents (approximately 95%) had attained formal education. Specifically, 39.75% ($n = 157$) of the participants had attained secondary level of education, 32.66% ($n = 129$) had primary education qualification, while a smaller number ($n = 90$, 22.78%) had achieved tertiary education. This suggested that most of the farmers in the sub-county had achieved basic education required for deeper understanding of the climate change impacts and the need to adopt adaptation as well as mitigation practices as observed by Atinafu *et al.* (2022) and Olayemi *et al.* (2020), who indicated that the rate of adoption of production technologies was dependent on the education level of the farmer.

The findings also implied that the literacy levels of the people living in Nyatike were fairly good. However, there were few farmers ($n = 19$, 4.81%) who did not possess formal education. The small number of those who had pursued tertiary education may have been attributed to the high rate of school dropouts due to the thriving economic activities like fishing and gold mining. Some of the people in the sub-county engaged in these economic activities and decided not to further their education upon completion of the basic levels. This confirms the finding of Makate *et al.* (2019) who reported that majority of the farmers in southern Africa had attained primary and secondary level of education which was considered as basic in influencing adoption of climate smart practices.

4.2.4 Crops Grown

Nyatike Sub-county's suitability for crop production is attributed to its favorable climatic conditions, particularly the bimodal rainfall patterns. These patterns allow farmers to plan planting seasons effectively and cultivate a diverse range of crops. The region experiences two crop cultivation seasons, during the short rains and another during the long rains. The crops grown by households were analyzed using frequencies, and the findings are presented in Table 9.

Table 9: Field Crops Grown by Farmers in the sub-county (N = 395)

Crops grown	Frequency (<i>f</i>)	Percent (%)
Maize	374	94.68
Beans	286	72.41
Sorghum	239	60.51
Rice	11	2.78
Sweet potatoes	243	61.52

According to the study findings presented in Table 9, there were notable variations in the types of crops grown across different households, with nearly all respondents cultivating multiple crops. Maize ($n = 374$, 94.68%) emerged as the most extensively cultivated crop across all the wards. This implied that maize is a staple source of food for the residents in the area. Other crops cultivated were beans, sorghum, sweet potatoes, and rice (72.41%, 60.51%, 61.52%, 2.78%) respectively. This showed that maize, beans, sorghum, and sweet potatoes were among the major crops grown by smallholder farmers. According to the findings the sizes of land allocated to each crop indicated that most crops were primarily grown for subsistence purposes, except for rice, which was commercially produced as reported by Ali (2021). Rice (2.78%) was reported as the least cultivated, predominantly in the Lower Kuja Irrigation scheme within North Kadem and Kanyasa wards. However, an interesting observation was made that some farmers from Got Kachola and Kaler had leased plots in North Kadem for rice farming explaining the distribution. The low percentage of rice farming suggests that rice is relatively new to the area and is not yet widespread among the local farmers, possibly due to various factors such as lack of knowledge, infrastructure, or market opportunities.

The other crops produced in the area included cassava (35.57%), vegetables (17.38%), groundnuts (16.6%), and tobacco (8.43%). This indicated that many of the farmers had diversified crop production to enhance their livelihoods and manage the risks of climate change. Crop diversification was seen as a risk management strategy, particularly in mitigating the impact of crop failure during unforeseen events or shocks. These findings are consistent with a study conducted by Ochieng *et al.* (2020), which also concluded that farmers in rural Kenya adopt crop diversification to manage climate-related risks. Other research studies, such as those by Vernoooy (2022) and Hashmiu *et al.* (2022), have suggested that the choice of climate adaptation technologies by a household is significantly influenced by the type of crops they cultivate.

4.2.5 Farm Acreage

The average farm size owned by the survey participants in acres was also assessed by frequencies, percentages, and means. Table 10 presents the sizes of land owned by the respondents.

Table 10: Total Farm Size Owned by Smallholder Farmers (N = 395)

Farm size (acres)	Freq (n)	Percent (%)
Below 2	49	12.41
2- 4	253	64.05
Above 5	93	23.54

Note: $M = 3.63$, $SD = 2.031$

The results in Table 10 indicated that more than half (64.05%) of the surveyed smallholder farmers had land size of between two and four acres. However, the mean farm size in the area was 3.63 acres ($SD = 2.03$). This suggested that many of the farmers in the sub-county were smallholder farmers. Generally, the size of land has been decreasing mainly due to the rising population and the culture of subdivision during the process of land inheritance. Land fragmentation hindered the mechanization of agricultural activities and large-scale farming. These findings align with the reports of Maja and Ayano (2021) who mentioned the decline in land holdings due to intergenerational fragmentation and population rise leading to an average farm size of 2.5 to 5 acres which could result in low income from agricultural production.

There were very few farmers ($n = 93, 23.54\%$) who owned more than five acres of land. This showed that the number of large-scale farmers in the subcounty was low compared to the majority who were small-scale farmers. The prevalence of small land holdings confirmed that many farmers have subdivided their lands, likely due to inheritance practices or land fragmentation over time. Interestingly, most farmers with more than five acres of land acknowledged the influence of land size on the type and number of climate change adaptation practices farmers were willing to adopt on their farms. This finding is in line with previous research conducted by Makate *et al.* (2019), which highlights the correlation between land size and farmers' adoption of adaptation practices. Larger landowners may have more resources and capacity to implement a wider range of adaptation measures compared to small-scale farmers as reported by Ojo and Baiyegunhi (2020). The limited number of large-scale farmers in the sub-county may have implications for the overall capacity to implement climate change adaptation practices on a larger scale. It also suggests the importance of providing targeted support to small-scale farmers, who constitute the majority, to enhance their adaptive capacity and resilience to climate change impacts.

Table 11: Land Allocation to Crops (N = 395)

Type of crop	Maize <i>Freq (%)</i>	Beans <i>Freq (%)</i>	Sorghum <i>Freq (%)</i>	Rice <i>Freq (%)</i>	Sweet potato <i>Freq (%)</i>
Below 2	46 (93.9)	32 (65.3)	29 (59.2)	1 (2.0)	25 (51.0)
2 – 4.9	236 (92.9)	190 (74.8)	155 (61.0)	9 (3.5)	159 (62.6)
Above 5	95 (100.0)	66 (69.5)	57 (60.0)	1 (1.1)	60 (63.2)

As shown in Table 11, maize crop ($n = 236, 92.9\%$) was allocated larger land area (Above 5 acres, 100%) compared to other crops. This suggested that maize was the staple food crop in the sub-county. Furthermore, majority of the maize varieties grown in the area withstands the changing climatic conditions. As indicated by the respondents, the total land allocated to agricultural production by a given household influences the choice of adaptation practices adopted in response to climate change. This is in line with Ali and Erenstein (2017) who reported that farmers with more land under production farmers are more likely to adopt climate-smart practices.

Other than maize, beans ($n = 66, 69.5\%$), sorghum ($n = 57, 60.0\%$), and sweet potatoes ($n = 60, 63.2\%$), were also allocated significant land sizes by most farmers. This

implied that farmers were aware of the benefits of crop diversification which is generally their contribution to food security and livelihoods as reported by Aryal *et al.* (2020) in South Asia. By diversifying their crop choices, farmers can enhance resilience to climate change, as different crops may have varying levels of tolerance to specific climate impacts. Planting of a diverse range of crops can help buffer against the risks associated with changing weather patterns and provide a more stable source of income and food for the farming communities in the sub-county. Additionally, crop diversification contributes to a healthy and sustainable farming system through maximum nutrient fixation and utilization (Nega, 2022),

4.2.6 Respondents Farming Experiences

A clear understanding of the prevailing climatic conditions of a place and the decision to put measures in place to manage the changes in climate would be dependent on the duration of involvement in farming in a specific area as postulated by the study. As such, the respondents were asked to indicate the number of years they had practiced agriculture in the sub-county. The duration of time spent in farming was quantified in terms of years for each respondent and summarized by frequencies and percentages. Table 12 presents the distribution of respondents by their experiences in farming.

Table 12: Distribution of Respondents by Farming Experiences (N = 395)

Farming experience(years)	Freq	Percent (%)
Below 10	106	26.84
10-30	216	54.68
Above 30	73	18.48
Total	395	100%

Note: $M = 19.73$, $SD = 13.91$,

The results in Table 12 show that slightly more half of the respondents (54.68%) had been in farming for a period of about 10 to 30years. Approximately 26.84% had less than ten years of farming experience, while 18.48% had farming experience of over thirty years. This suggested that various farmers in the sub-county had accumulated necessary expertise in agricultural production. On average, the respondents had 19.8 ($SD = 13.91$) years of experience, with minimum being 1 year and the maximum being 75 years. The relatively high standard deviation (13.91 years) compared to the mean (19.8 years) indicates that there's significant variability in the respondents' farming

experience. The range from 1 to 75 years suggests a wide diversity in the level of experience within the surveyed population. However, it also implies that all respondents possessed farming experience and were likely exposed to the local weather trends. These findings are in line with the reports of Rondhi *et al.* (2019) established farmers who were actively involved in rice farming were more experienced in farming compared to others thus had accumulated more years of practical experience.

Farming experience had an impact on individuals' ability to navigate weather events and make informed decisions to adapt to associated risks as reported by Thinda *et al.* (2020) and Mashi *et al.* (2020). Previous studies have reported a positive correlation between longer farming experience and the adoption of agricultural technologies. Longer farming experience often implies the accumulation of farming knowledge, technical know-how, and skills, which collectively contribute to the adoption of new technologies (Kumar *et al.*, 2020).

4.3 Level of Awareness of Climate Change Impacts

The first objective sought to determine awareness of climate change impacts in Nyatike sub county and its influence on adoption of the climate adaptation technologies.

4.3.1 Farmers Awareness of Changes in Weather Patterns

The respondents were requested to indicate their perception of changes in weather pattern within the sub-county over the past 20 years. This information was summarized by use of frequencies and percentages as presented in Table 13.

Table 13: Perception of Farmers on Changes in Weather Patterns (N = 395)

Changing weather	Frequency (<i>f</i>)	Percentage (%)
No	4	2.0
Yes	391	98.0

The findings presented in Table 13 indicate that that a significant majority (98%) of the respondents had observed general changes in the weather patterns over time within the region. This high percentage indicates an increasing rate of perception regarding changes in weather patterns. The level of awareness of climate variations in the study area is comparable to that of South Africa (86%) (Talanow *et al.*, 2021). However, it is

notably higher than Nigeria, where only 75.2% of farm households were observed to be aware of changes in rainfall patterns (Galadima *et al.*, 2020). These findings align with previous studies that have highlighted the growing awareness among farmers concerning climate variability and change not only in Kenya but also in other regions. It is important to acknowledge that awareness and perceptions regarding climate change vary with regions. Developed countries tend to have higher levels of awareness regarding climatic variations compared to developing countries such as Asia, the Middle East, and Africa. This explains the disparities in the findings (Asante *et al.*, 2021; Silveira *et al.*, 2022).

However, it is worth noting that a small portion of respondents (2%) still believed that the weather in the area had remained constant over the past ten years. This highlights the need for further community sensitization to enhance their understanding of the emerging climate threats in the area.

4.3.2 Awareness of Climate Parameters and their associated risks

To gain more insight on the changing climate parameters smallholder farmers were asked to rate their level of awareness regarding these climate parameters and their impacts. The responses were computed by frequencies and percentages. Table 14 presents the respondents awareness level.

Table 14: Awareness of Climate Change and the associated risks.

	Variable	Aware <i>n</i> (%)	Unaware <i>n</i> (%)	Neutral <i>n</i> (%)
Parameters	Prolonged Rains	272(68.80)	70(17.70)	53(13.40)
	Delayed rains	382(96.73)	7(1.80)	6(1.47)
	Extreme Temperature ranges	363(86.60)	3(0.80)	49(12.40)
Associated risks	Invasive weeds	305(77.30)	31(7.90)	59(14.90)
	Pest and diseases	371(93.90)	2(0.50)	22(5.60)
	Drought	388(98.30)	1(0.30)	6(1.50)
	Floods	287(72.70)	58(14.70)	50(12.60)
	Crop failure	383(97.00)	-	12(3.00)
	Loss of livestock	302(79.00)	36(8.90)	59(14.90)

The results in Table 14 show a considerable proportion of farmers ($n = 363$, 86.60%), reported being conscious of the changing temperature ranges. This implied they have

observed the unusually high or low temperatures in the area. About 68.80% ($n = 272$) of the respondents indicated to have witnessed extended periods of rainfall. However, a significant percentage of farmers ($n = 382$, 96.73%) acknowledged being aware of the delays in onset of rains resulting to drought ($n = 388$, 97.99%). The higher response on delayed rains suggested that this is among the great impacts of climate change in Nyatike sub-county. The study's results are in line with the findings of Shrestha *et al.* (2022), who also reported that farmers frequently encounter hazards due to unpredictable rainfall patterns. These often have adverse effects on agricultural production, reducing household income and exacerbating the economic impacts especially on subsistence farmers. Additionally, farmers identified invasive weeds (77.30%), pest and disease proliferation (93.90%), flooding, drought, and crop failure and loss of livestock (72.70%, 98.30%, 97.00%, 79.00%) respectively as the most common risks associated with climate change.

These findings align with a study conducted by Akanbi *et al.* (2021) which reported that respondents had a perception of climate-related risks, including frequent drought occurrences, severe pest infestations, higher temperatures, and increased disease occurrences. However, it is important to note that some farmers expressed lack of awareness regarding these climate parameters and their associated impacts, while others were undecided about their experience of climate change impacts. This may have affected the rate of adoption of climate adaptation practices since lack of awareness has been reported to associate negatively with adoption of new technologies (Atinafu *et al.*, 2022). Despite this, the overall trend suggests a growing awareness of climate change parameters among farmers in Nyatike sub-county. Further, the study also reported increased frequency of erratic rainfall patterns, leading to incidents of flooding. These occurrences are attributed to both the overflowing of rivers and the increasing water levels of Lake Victoria.

4.3.3 Effect of Climate Change on Agricultural Production

The sampled farmers were asked to indicate the perceived effects of climate change on farming. Results were summarized by use of frequencies and percentages as shown in Table 15.

Table 15: Effect of Climate on Agricultural Production

Effects of climate change on agriculture	Frequency	Percentage
Decreased soil fertility	64	16.2
Drying of crops from the intense heat	40	10.0
Floods destroying crop fields and domesticated animals	56	14.0
Increased postharvest losses of crops	78	19.5
Intensive growth of weeds	24	6.0
Outbreak of pests and diseases for crops and livestock parasites	23	5.8
Reduction in crop yield	60	15.0
Soil erosion from runoff due to high rainfall intensity	50	12.5

Results in Table 15 revealed that climate change is posing a range of challenges to agricultural activities. A significant proportion of respondents (19.5%) reported increased postharvest losses as the most prevalent effect, which may result from factors like unpredictable weather and elevated temperatures impacting crop storage and quality. Additionally, 16.2% of respondents noted a decline in soil fertility, likely due to intensified soil erosion, nutrient loss, and changes in soil composition, which threatens overall agricultural productivity. Reduction in crop yields was also commonly cited (15.0%), reflecting the adverse impacts of extreme weather events, such as erratic rainfall and temperature fluctuations, which disrupt growth cycles and reduce harvests. Flooding, another major concern, was reported by about 14.0% of participants, highlighting the damage to crops and livestock caused by increased rainfall and severe weather events. However, it is worth noting, that this damage remained relatively low, particularly in the hilly wards such as Macalder, Got-kachola, and Kaler.

Other impacts of climate change include soil erosion due to heavy rains (12.5%), drying of crops from extreme heat (10.0%), intensive weed growth (6.0%), and outbreaks of pests and diseases (5.8%). These findings indicate that a broad spectrum of climate-related factors is negatively affecting various aspects of agricultural productivity. The evidence suggests a need for targeted adaptive measures, such as improving soil conservation practices, enhancing storage facilities, and adopting integrated pest management strategies to mitigate the negative effects of climate change on farming communities. These findings are consistent with the conclusion drawn by Gowda *et al.* (2018), indicating that the spread of pests and diseases, reduced yields, and loss of livestock are among the significant climate change impacts on agriculture production.

The observed impacts of climate change on farming are directly linked to changes in rainfall patterns and temperature. These changes resulted in either longer or shorter rainy seasons. Farming households expressed concerns about the decreasing crop yields, compromised crop quality, and overall crop and livestock losses. The reduction in yields may have resulted from the delayed rains, pest, and disease infestation, and extremely high temperatures. The findings agree with those of Liu & Desai, (2021); Amale, *et al.* (2023), who reported the sensitivity of crops to heat stress and negative effects of delayed rains, which result in shorter growing period. IPCC (2022) also reported that moderate temperature increase had a positive effect on crop yields in temperate regions. However, tropical regions and semi-arid areas were expected to face negative consequences, including a decline in crop yields.

It was also reported by the sampled farmers that the devastating soil erosion witnessed in the area was attributed to surface runoff and flooding, triggered by escalating intensity of rainfall. These factors have led to crop damage and losses, which ultimately affect the overall crop yields as reported by Ochieng *et al.* (2017). However, the effects of climate change are contingent upon the pace of climate parameter changes and the farmers' capacity to adapt. The farmers' perception of these impacts plays a pivotal role in their decision-making process concerning the adoption of climate adaptation practices. Furthermore, other farmers indicated a heightened prevalence of food insecurity attributable to the decline in food production. These results correspond to the reports outlined by Richardson *et al.* (2018), emphasizing the growing risks posed by climate change to agricultural practices and the productivity of crops. Particularly in countries reliant on natural production systems vulnerable to climate change such as Asia and Sub-Saharan Africa.

4.3.4 Climate Change Awareness and Adoption of Adaptation Practices

The first objective sought to assess awareness of climate change impacts and its influence on the adoption of climate adaptation practices among smallholder farmers. A one-way Analysis of Variance was conducted to investigate if adoption of adaptation practices differed based on the levels of awareness. The test involved adoption of adaptation practices as continuous variable while the independent variable was the

categorical independent variable with three levels: undecided, aware, and highly aware. Table 16 presents the summary statistic.

Table 16: Analysis of Variance Results for Awareness Levels on Climate Change and Adoption of Adaptation Practices

Awareness level	<i>M</i>	<i>SD</i>	<i>df</i>	<i>F</i>	<i>P</i>
Undecided	112.85	45.95	2	11.389	0.00*
Aware	121.70	31.03	2		
Highly Aware	137.29	29.35	2		

The results in Table 16 showed that there was a significant effect of awareness level on adoption of adaptation practices at $p < 0.05$ level for the three levels of awareness ($F(2, 392) = 11.389, p = 0.00$). The effect size, eta squared (η^2), was 0.07% indicating a moderate effect of awareness level of adoption of adaptation practices. Post hoc comparisons were conducted using Games-Howell tests which revealed that the mean adoption level for the highly aware group ($M = 137.29, SD = 29.35$) was significantly ($p < 0.05$) higher than the aware ($M = 121.70, SD = 31.03$) and the undecided group ($M = 112.85, SD = 45.95$). However, there was no significant difference in adoption between the undecided and aware group $p = 0.54$. These results suggested that the degree of awareness influenced the adoption of the adaptation practices. Specifically, the results suggested that farmers who were highly aware of the climate change impacts reported greater levels of adoption of adaptation practices. However, the awareness level should be high enough to trigger a significant effect in the adoption of the practices.

The highly aware group may have adopted the practices much more than the other groups out of the deep understanding of devastating effects of climate change. For instance, in response to increased awareness of challenges such as rising evapotranspiration, higher rainfall variability, and reduced predictability farmers have predominantly directed their efforts towards adopting water and soil management practices. Moreover, they embraced the use of drought-tolerant cultivars to improve their resilience in coping with these evolving environmental conditions (Zhao *et al.*, 2022). Therefore, knowledge of climate change shaped farmers to clearly understand and tackle the consequences of the phenomenon, encouraged them to change their behavior motivating them to adopt the practices. These findings agree with those of

Fahad and Wang, (2018); Wetende *et al.* (2018) and Akanbi *et al.* (2021), who concluded that farmers level of awareness plays a crucial role in driving behavioural change and the adoption of new practices in agricultural systems.

There is need to create adequate awareness about climate change and its impacts not only on agriculture but also on people's livelihoods. Farmers need adequate access to knowledge not only on the effect of the change and ways of preventing and mitigating those effects in order to take appropriate measures. This confirms the argument by Abid *et al.* (2019 and Abbasi and Nawaz (2020), that climate change awareness significantly correlates with adaptation in the agricultural sector, as increased knowledge about climate change enhances farmers' capacity to undertake more effective adaptation interventions. Even though there could be several factors influencing farmers' awareness that in general would affect their adoption rate. Therefore, extension comes in to play a pivotal role in using appropriate channels and approaches to create awareness of climate impacts and possible adaptation technologies.

4.4 Extension Delivery Channels and Adoption of Adaptation Practices

The study sought to identify the channels that were used to disseminate climate adaptation practices information, the effectiveness of extension delivery channels, and the effect of the information sources on adoption of the adaptation technologies. This was intended to identify the most effective and commonly utilized channels that would be recommended for use not only in the study area but also in other regions with similar conditions.

4.4.1 Channels Utilized to Create Awareness of Climate Impacts and Climate Adaptation Practices Information

To determine the most utilized extension delivery channels, the respondents were asked to indicate where they obtained information about climate change, its impacts, and adaptation practices. The channels were then ranked based on their usage as shown in Table 17.

Table 17: Extension Delivery Channels for Disseminating Information on Climate Adaptation Practices

Extension channels		Freq(<i>f</i>)	Percent (%)
Mass media channels	Radio	367	92.21
	Television	330	82.91
	Print media	146	36.68
	Phone	172	43.22
	Internet	141	35.43
Interpersonal channels	Farmer to farmer	356	89.45
	Public gatherings	329	82.66
	Agricultural shows	203	51.01
	Farmer field schools	161	40.45
	Government Extension agents	183	45.98
	Private Extension agents	175	43.97

As presented in Table 17, majority of the respondents obtained information relating to climate change impacts, adaptation, and mitigation from mass media channels. Mass media channels served as the primary passageway of diffusion of information relating to climate change. Among the mass media channels, the radio ($n = 367$, 92.21%) and the television ($n = 330$, 82.91%) emerged as the main outlets. This suggests that traditional media still play a significant role in reaching a broad audience, likely due to its widespread accessibility across various households. The use of the radio and television to share climate change knowledge may have been enhanced by the diversity of languages used by various radio and television stations as well as the simplicity of the messages. This finding agrees with results reported by Antwi-Agyei and Stringer (2021) that the common source of agricultural information in rural areas is local radio and TV stations. Particularly, Ramogi TV and FM stations were the most commonly utilized channels as pointed out by the respondents. These channels leveraged the use of local languages to reach a wider audience. The radio and television were also preferred by the extension department due to their cost-effectiveness and ability to reach diverse audiences. Many of the farmers argued that the two delivery channels were the most accessible. According to the farmers, the radio had proven to be inclusive as it demanded lower literacy levels than the other media platforms. This is in consonance with the findings of Kassem *et al.* (2019) that radio cuts across all the literacy levels and reduces barriers associated with other mass media like newspapers.

Mobile phones ($n = 172$, 43.22 %) and print media ($n = 146$, 36.68%) were ranked third and fourth respectively among the mass media channels by most respondents. The use of mobile phones to disseminate agricultural information had intensified in the recent past due to its adoption by private and public extensionists. The meteorological department have also adopted the use of text messages (SMS weather alert system) to inform farmers/people about the changes in weather. The SMS weather alert systems specifically, informed people about changes in temperature, rainfall patterns, and the likelihood of occurrence of climate change hazards like flooding. Informing the farmers of the looming weather-related events in advance has become obligatory to avoid the harm that an unprecedented catastrophe brings along with it. The respondents also noted that other than text messages, climate change information was also shared via phones through calls and WhatsApp platforms. These findings confirmed the results of the study conducted by Etwire *et al.* (2017) that the rapid growth of mobile phones has opened the possibility of delivering relevant and timely weather information to farmers at costs lower than other conventional extension services.

Among the print media channels, newspapers and brochures were the most utilized materials in sharing climate change adaptation information. The print media was unable to reach as many people as those communicated to by the radio and television because it locked out those without formal schooling. The print media uses the national languages; Kiswahili and English to pass messages thus, illiterate farmers are left out unless the messages are translated for them. Very few farmers ($n = 141$, 35.43%) had utilized internet services to access climate adaptation information particularly those who were well educated. Use of internet requires skills that many of the farmers may not have. This explains why it was unpopular and the least utilized channel. The findings are in line with those of Zheng *et al.* (2021). However, Ma and Wang (2020) reported a positive and statistically significant impact of internet on the number of sustainable agricultural practices that farm households adopted.

Regarding interpersonal channels, exchange of information between farmers (89.45%) and public gatherings (82.66%) emerged as the main outlets for climate adaptation information to farmers within the sub-county. The prevalence of farmer-to-farmer exchanges suggested significance of peer learning and knowledge-sharing within

farming communities. Furthermore, farmers trust and value the experiences and practices shared by their peers, making farmer-to-farmer interactions an effective means of disseminating information on climate adaptation.

On the other hand, public gatherings such as the Chief's barazas and social events, provided valuable opportunities for extension agents and experts to directly engage with farmers and discuss various climate impacts and possible adaptation practices. Farmers revealed that face-to-face interactions promoted trust and facilitated two-way communication between with the experts, fostering a better understanding of agricultural challenges and solutions through adoption. Parallel conclusions have been drawn by Khan and Akhtar (2019), who found comparable results. In their study, they found that a significant majority of surveyed farmers, specifically 95.3%, preferred farmer exchanges as communication channels for accessing agricultural information. They highlighted a notable inclination towards face-to-face discussions and the involvement of change agents to facilitate the adoption of innovations.

Agricultural shows or trade fairs were accessed by slightly more than half of the respondents (51.01%) and it emerged as the third commonly used extension channel to access climate risk and adaptation information in the sub-county. The use of agricultural shows in the recent past have been embraced to showcase advanced technologies by most research institutions to promote dissemination of sustainable agricultural practices as well as climate adaptation practices. The respondents indicated that the shows occurred once a year in Migori show ground where climate adaptation information was shared through result demonstrations, presentations, exhibitions, and discussions. Additionally, the agricultural shows offered opportunities for farmers to interact with experts, organizations, and businesses to learn new climate adaptation technologies.

The respondents also acknowledge the role played by the government extension agents (45.98%) and private extension agents (43.97%) in dissemination of climate related information. This implied that extension agents still serve as critical information sources building farmers knowledge and skills through frequent contacts and follow up visits. Extension agents have been an integral part of the agricultural system and farmers acknowledged their continued effort in promoting crop production through

trainings and adoption of new innovations. However, the lower percentage could be attributed to the fact that the extension agents to farmer ration in Nyatike sub-county is low limiting their impact in delivering timely and frequent climate adaptation information. This is because the entire sub-county is served by one sub-county extension officer (SCAO).

Therefore, some farmers preferred access of information through private extension purposing that it is more efficient compared to public extension due to the growing population of smallholder farmers. The low contact with extension agents could result in low adoption due to lack of knowledge, reinforcement, and follow up visits. The challenges experienced in the public extension has been reported by (Anang *et al.*, 2020; Sennuga *et al.*, 2020, especially in developing countries leading to privatisation of extension services. Similarly, Musafiri *et al.* (2020), concluded that low contact with extension agents might have contributed to low access to extension services resulting in low proportion of income from crops.

Less than half of the farmers (40.45%) had utilized farmer field schools as sources of adaptation information. This suggested that farmer field schools compared to other interpersonal channels was the least utilized. However, as a group extension method it has been embraced by the extension department to share ideas and practical lessons on climate adaptation. This has helped in a great way to address the problem of growing extension staff to farmer ratio. The respondents acknowledged its value in terms of learning and networking opportunities, which allowed farmers to stay updated on the latest advancements in climate adaptation practices. This was particularly important given the ongoing campaign for climate-smart agriculture (CSA) facilitating the sharing of innovation and knowledge to encourage the adoption of these practices. Similar results were reported by Mfitumukiza *et al.* (2017), where Farmer Field Schools emerged as a means to advance climate adaptation, particularly in rural areas.

4.4.2 Effectiveness of Extension Delivery Channels in Dissemination and Adoption of Climate Adaptation Practices

To check whether the farmers were getting adequate and timely information on climate change adaptation, the effectiveness of extension delivery channels was examined. The

respondents were given a set of channels and were asked to indicate their levels of effectiveness in diffusing adaptation information. The results were summarized by use of mean scores and the standard deviations. Table 18 presents the results on effectiveness of the different extension channels.

Table 18: Effectiveness of extension Delivery channels in Disseminating Climate Change Adaptation Practices

Channel	Highly effective (%)	Effective (%)	Moderately Effective (%)	Not Effective(%)
Public gatherings	23.8	46.5	27.4	2.3
Home and farm visits	24.9	59.4	65.6	3.5
Demonstrations	20.5	46.6	27.3	5.6
Extension agents	24.6	45.3	29.4	0.8
Television	25.0	42.3	32.2	0.5
Radio	35.4	44.1	20.5	-
Phone/internet	10.2	36.7	39.5	13.5
Exchange visits	28.1	49.1	22.5	0.3
Farmer field school	17.2	48.4	30.9	3.5

Note: 1= Not effective 2= Moderate, 3= Effective, = Highly Effective

According to the results in Table 18, the radio (35.4%) and exchange visits (28.1%) were ranked as highly effective extension channels. This implies that both the radio and exchanges provided timely and relevant information about adaptation practices to the farmers. Notably, farmers highlighted that radio programs were broadcasted in the afternoon, after their farming activities, which contributed to a high listenership. This aligns with similar observations made by Mtega (2018), who concluded that farmers preferred radio programs in the afternoons despite many programs being aired in the morning, owing to the availability of replays in the afternoon. The strategic timing of broadcasts and the possibility of replays appear to have contributed to the efficacy of this channel in reaching and engaging the farming community. These insights are in line with previous research, reaffirming the importance of considering timing and convenience when designing communication strategies for agricultural extension (Nwalieji *et al.*, 2019).

Farmer exchanges were rated as most effective particularly in regions where experienced farmers or those with extensive knowledge about specific practices lived. These experienced farmers served as valuable sources of advice, offering guidance to

other farmers who sought consultations. This underscores the significance of farmer-to-farmer information exchange especially in areas with few extension agents. This showed that farmer exchanges as an interpersonal channel played a pivotal role in positively influencing behavioural changes and promoting the adoption of adaptation practices. This finding aligns with the observations made by Iqbal *et al.* (2023), affirming the crucial role of interpersonal communication in facilitating behaviour change and the successful uptake of adaptation practices.

Television (25.0%), interaction with extension agents (24.6%), and public gatherings (23.8%) were also ranked effective as they provided adequate awareness and adaptation information. Their effectiveness can potentially be attributed to their direct and interactive nature, enabling engagement, clarification, and customized guidance. The respondents revealed that channels such as group discussions, extension agents, and public gathering acted as a reinforcement to the information they access through mass media channels. The additional information gotten through these channels enhanced the adoption of the practices. The combination of these extension channels to provide adequate information resonates with the findings of Khan and Akhtar (2019), who highlight that the synergy of mass media and interpersonal channels amplifies their collective effectiveness. This suggests that a holistic approach, combining different communication methods, can yield more impactful outcomes in promoting the adoption of adaptation practices among farmers.

Interestingly, the utilization of mobile phones was reported at a lower percentage (10.2%) compared to other channels as being highly effective in reaching farmers with climate adaptation practices information. This suggested that farmers have not embraced the use of cell phone in sharing agricultural information. Many of the farmers especially those with little or no formal education utilized phones mainly for normal conversations and not for information gathering. This finding seems to contrast with the conclusions drawn by Obeng *et al.* (2019) who reported that mobile phones improved farmers' awareness of agricultural information. This inconsistency could be attributed to factors like inadequate network connectivity or a lack of awareness regarding the role of mobile phones in facilitating access to climate adaptation information. However, it's important to note that lower effectiveness didn't necessarily

indicate that it wasn't utilized only that its usage was not as effective as the other channels.

4.4.3 Factors Limiting the Effectiveness of Extension Delivery Channels

To understand some of the factors contributing to low effectiveness of extension delivery channels the respondents were asked to indicate some of these factors. Table 19 illustrates the constraints that hindered the efficiency of both the mass media and interpersonal extension delivery channels.

Table 19: Factors Limiting the Effectiveness of Extension Delivery Channels

Factors	Freq(<i>f</i>)	Percent (%)
Low cooperation among farmers	180	45.56
Inappropriate use of dissemination channels	272	68.86
Low frequency of existing extension programs	294	74.43
The incompetence of the extension personnel	254	64.31
Low turnout for the meetings	244	61.77
High extension to farmer ratio	349	88.36

The results presented in Table 19 revealed that majority of the respondents agreed that high extension – farmers ratio ($n = 349$, 88.36%) and low frequency of implementing extension programs ($n = 294$, 74.43%) were the major factors hindering effectiveness of extension channels in disseminating climate adaptation information. The shrinking number of extension agents resulted from failure of county government to replace and hire new staff to meet the growing population of farmers in the sub-county. The lower number of extension agents resulted in few numbers of contacts between the agents and the farmers thus limiting timely information sharing. These findings are in line with Sennuga *et al.* (2020), who reported that majority (89%) of the respondents perceived lack of regular contacts with extension agents as a great challenge to technology uptake especially among smallholder farmers.

Additionally, inappropriate use of dissemination channels ($n = 272$, 68.86%), incompetence of the extension personnel ($n = 254$, 64.31%) and low turnout for the meetings ($n = 244$, 61.77%) were also mentioned as key barriers to effectiveness of the extension delivery channels. The incompetence of the extension agents was attributed to lack of in-service training, inadequate information sharing resources, and lack of exposure to the new information communication technologies. The effectiveness of

extension services depended on the choice of appropriate channels, nature of information, target audience, and the available resources.

The apprehension regarding incompetence of the extension personnel indicated that a notable proportion of the respondents believe that the efficiency of extension programs is compromised by the lack of competence among the personnel delivering the information. In essence, respondents felt that the extension staff may not possess the necessary knowledge or expertise to deliver accurate and helpful information, which in turn could hinder the overall success and impact of the extension initiatives in promoting climate adaptation. Climate change adaptation is multifaceted and an emerging area of concern and this might be one of the challenges experienced by the extension personnel and farmers in trying to promote context specific adaptation practices leading to low success (Sennuga *et al.*, 2020).

Low turnout for the meetings ($n = 244$, 61.77%) specifically pointed to the challenge of getting farmers to attend extension meetings and engage with extension activities as well as listen and follow extension programs. The low turnout for meetings resulted from failure of the extension agents to inform all the farmers in advance, inadequate involvement of the stakeholders, and lack of proper planning. Proper planning and execution of extension programs required adequate resources which may have been unavailable. Farmers indicated that their schedules conflicted with those of the extension programs, and this posed a significant obstacle to their consistent participation in training sessions and experimental trials. This was particularly attributed to the fact that many extension activities were scheduled on market days, a time when farmers are engaged in selling their produce. Consequently, the scheduling conflict emerged as a major hindrance to their active participation as reported by Suvedi *et al.* (2017).

Nonetheless, the issue of low cooperation among farmers ($n = 180$, 45.56%) was mentioned as the least limiting factor affecting effectiveness of the delivery channels. The effectiveness of each extension channel in reaching its intended audience also relied heavily on the audience's willingness to engage with mass media broadcasts or participate in interpersonal discussions. These findings align with the reports of Vijayalingam *et al.* (2019), that low turnout for training on rabbit farming indicated

lack of willingness among farmers. The fact that this percentage was just below half suggests that the respondents generally expressed a willingness to actively partake in these programs and to experiment with new practices to achieve successful adaptation.

4.4.4 Extension Delivery Channels and Adoption of Climate Adaptation Practices

To determine the relationship between the extension delivery channels and adoption of climate adaptation practices, ordinal logistic regression was used to assess the influence of Mass Media and Interpersonal extension communication channels on the likelihood of being in different categories of adoption of climate adaptation practices (Low, Moderate, or High). The dependent variable (Adoption) was ordinal, and the model used a logit link function. Table 20 presents the analysis.

Table 20: Ordinal Logistic Regression for Association between Extension Delivery Channels and Adoption of Adaptation Practices

		Estimate	Std. Error	Wald χ^2	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Adoption = 0]	-.510	.267	3.637	1	.057	-1.034	.014
	[Adoption = 1]	.954	.269	12.583	1	.000	.427	1.481
	Mass media	2.123	.467	.069	1	.012	1.039	2.793
Location	Interpersonal channels	1.957	.449	18.975	1	.000	1.076	2.837

Link function: Logit.

The reference category for the dependent variable (Adaptation) is "High

Overall, the model results in Table 20 indicated that access to adaptation information through mass media and interpersonal channels had a significant relationship with adoption of the climate adaptation practices. Information access through interpersonal channels had a positive and statistically significant impact on adoption of the adaptation practices. The coefficient for interpersonal channels was 1.957 (SE = 0.449, Wald $\chi^2 = 18.975$, $p < 0.05$), indicating a highly significant positive effect. This suggests that interpersonal communication methods, such as farmer-to-farmer interactions, public gatherings, and farmer field schools, greatly increase the likelihood of being in a higher adoption category. For every unit increase in the use of interpersonal channels, the odds of being in a higher adaptation category increase by a factor of approximately 7.08 (Exp(B) = 7.08).

Interpersonal communication channels such as farmer to farmer exchanges, contact with extension agents and other interpersonal channels were very crucial in disseminating information to farmers thus successful adoption of climate adaptation practices. Specifically, most of the respondents revealed that farmer exchanges and public gatherings greatly influenced their interest and adoption decisions. This suggested that face to face interactions promoted learning from experts through discussions, observation and practice leading to successful adoption. These findings align to those of Njeri and Mberia (2019), who reported a perfect positive correlation between interpersonal group methods and adoption of organic farming. Further, they reported an increased interest in group interpersonal communications of agricultural technologies among farmers compared to mass media.

Further, the coefficient for mass media channels was 2.123 (SE = 0.467, Wald $\chi^2 = 0.069$, $p = 0.012$). This positive and statistically significant result ($p < 0.05$) suggested that an increase in the use of mass media channels, such as radio, television, print media, and the internet, was associated with higher odds of being in a higher adoption category. Specifically, for each unit increase in the use of mass media, the odds of moving to a higher adaptation category increased by a factor of approximately 8.36 (Exp(B)). Specifically, respondents highlighted the significant role of radio and TV promoting adoption of these practices attributed to their potential to reach a diverse audience with timely climate-related information. These findings confirm the reports of Junsheng *et al.* (2019), that mass media contributed positively to awareness, knowledge and change of attitude towards environmentally friendly practices.

However, there could be other factors beyond exposure to the extension channels that might have contributed to the adoption of these practices. Notably, in accordance with the Rogers diffusion of innovation theory, various other factors, including the social system, time, and characteristics of the innovation itself, such as trialability, relative advantage, observability, compatibility, and complexity, could have had an impact on the adoption of the adaptation practices. Moreover, according to Shahbaz *et al.* (2021), adoption of climate change strategies at farm level was influenced by schooling years, age, machinery ownership, market distance, agricultural labor force, extension services and total land ownership.

These findings suggest that both interpersonal channels and mass media play significant roles in shaping the adoption of the adaptation practices by smallholder farmers in Nyatike. Interpersonal channels appear to have a stronger influence, as indicated by the larger coefficient compared to mass media. This is because the interpersonal channels such as farmer-farmer exchanges, contact with extension agents provide hands-on explanations, demonstrations and discussions of the practices which emphasizes the knowledge obtained through the mass media channels. These findings align with Antwi-Agyei and Stringer (2021), who also reported the positive influence of agricultural extension channels on the adoption of adaptation practices. The study suggested that the efficacy of adopting adaptation practices tends to increase during the initial stages of introducing these practices to farmers, particularly when utilizing mass and individual extension approaches.

4.5 Effectiveness of Project-Based Extension Approach in Enhancing the Adoption of Climate Change Adaptation Practices

Objective three aimed to assess the effectiveness of the project-based extension approach in enhancing the adoption of climate change adaptation practices. This was discussed in terms of adequacy and training frequency under the project-based extension approach. The results were summarized as shown in the section.

4.5.1 Effectiveness of the Project-Based Approach

The participants were asked to rate the effectiveness of project-based extension approach on a scale ranging from 1 (Not Effective) to 4 (Highly Effective) in conducting different activities related to climate change adaptation, as shown in Table 21.

Table 21: Effectiveness of Project-Based Approach (N = 395)

Adaptation activity	Highly effective (%)	Effective (%)	Slightly effective (%)	Not effective (%)
Creating awareness of climate change impacts	17.7	57.7	20.5	4.1
Follow up visits	31.6	43.5	16.7	8.1
Giving relevant and timely information on climate adaptation practices	12.7	58.7	25.1	3.5
Early warnings on climate trends	12.7	67.6	19.5	0.3

Note: = 4-Higly Effective; 3-Effective; 2-Slightly Effective; 1-Not Effective

Results revealed that the activity of conducting follow-up visits within the project was rated as the most effective activity, with 31.6% of respondents considering the highly effective and 43.5% rating it as effective. This high level of positive feedback suggests that direct engagement through follow-up visits plays a critical role in fostering the adoption of climate adaptation practices. Nevertheless, 16.7% of respondents rated this activity as slightly effective, and 8.1% as not effective, indicating that the effectiveness of follow-up visits may not be uniformly experienced across all farming households. Similarly, creating awareness of climate change impacts was generally perceived positively, with 57.7% of respondents rating it as effective and 17.7% as highly effective. However, 20.5% of respondents considered it slightly effective, and 4.1% not effective. These mixed perceptions suggest that while efforts to raise awareness are appreciated by the majority, a considerable proportion of farmers remain unconvinced about its overall effectiveness, potentially due to differences in how the information is presented or its relevance to specific local contexts.

Regarding the provision of relevant and timely information on climate adaptation practices, 58.7% of respondents rated this activity as effective, while 12.7% found it to be highly effective. However, 25.1% rated it as slightly effective, and 3.5% deemed it not effective. These results point to a perceived gap in the relevance or timeliness of the information provided, suggesting a need to tailor communication more closely to the specific needs and circumstances of different farmers. Furthermore, the approach highly rated in delivering early warnings on climate trends, with 67.6% of respondents considering it effective and 12.7% rating it as highly effective. This strong positive response indicates that early warnings are widely trusted and valued as a crucial component of climate adaptation strategies, highlighting their importance in helping farmers make timely and informed decisions.

The overall pattern of results indicates that the activities within project-based extension approach positively impacts various aspects of climate change adaptation. Previous studies have often emphasized the significance of timely and relevant information dissemination in climate change adaptation. The substantial effectiveness attributed to follow-up visits and early warnings on climate trends aligns with the notion that personalized interactions and proactive measures can significantly enhance climate

change adaptation. These findings resonate with earlier research underscoring the importance of continuous support and tailored guidance for effective adaptation practices (Galadima *et al.*, 2020).

4.5.2 Adequacy of Project-Based Extension Approach

The results, presented in Table 22, shed light on the perceived adequacy of the project-based approach in promoting the adoption of climate change adaptation practices.

Table 22: Perceived Adequacy Project-Based Approach

Adequacy of Project-Based Approach	M
Conducting awareness meetings to sensitize farmers on climate change adaptation	4
Conduct field days to publicize new and improved technologies of crops, and livestock that is drought and disease resistant.	4
Conducting demonstrations to farmers on new knowledge and skills in climate change adaptation practices	3
Training farmers on proper practices to increase shelf life and reduce postharvest losses.	3
Linking farmers to relevant research institutions for on-farm adaptive research on smart practices for climate change adaptation.	4

The evaluation of various activities conducted within the approach towards climate adaptation, highlighted distinct levels of perceived adequacy among respondents. Awareness meetings aimed at sensitizing farmers about climate change adaptation were deemed highly adequate, with a median score of 4. This result indicated that respondents viewed these meetings as an appropriate means of increasing farmers' knowledge and preparedness regarding climate change impacts and adaptation strategies. Likewise, field days, were conducted to showcase new and improved technologies for drought- and disease-resistant crops and livestock and linking farmers to relevant research institutions for on-farm adaptive research were similarly rated as highly adequate (M = 4). However, in conducting demonstrations and training on postharvest practices were considered moderately adequate (M = 3). This suggested that while respondents recognized the utility of these methods, they perceived them as only moderately effective in imparting practical knowledge and reducing postharvest losses. This feedback indicated a potential need for enhancements in these approaches to improve their overall adequacy.

These findings align with earlier research while introducing nuances that contribute to understanding extension strategies for climate change adaptation. Prior studies indicated similar moderate effectiveness levels for project-based approaches, and the current study's results corroborate that trend (Abbasi & Nawez, 2020). However, the unique contribution lies in the specific context of climate change adaptation, where factors such as the urgency of implementation and the complexity of adaptive practices can influence farmers' perceptions (Akanbi *et al.*, 2021).

Additionally, the variability in responses emphasizes the importance of tailoring extension approaches to smallholder farmers' diverse needs and circumstances. While some farmers might have found the project-based approach adequately effective, others could have specific preferences for alternative information dissemination and support methods. This underscores the need for a flexible and multifaceted extension strategy that incorporates various channels to ensure broader reach and higher effectiveness in promoting climate change adaptation practices as reported by Silveira *et al.* (2022).

4.5.3 Training Frequency among Farmers

Table 23 presents a breakdown of the respondents' training frequency, categorized into four distinct levels: Never, occasionally (Irregular), Often (Monthly), and Very Often (Fortnightly). The results offer insights into the participants' engagement with training efforts in the Nyatike sub-county.

Table 23: Training Frequency in Nyatike Sub- County

Responses	Frequency.	%
Never	27	6.8
Occasionally (Irregular)	296	74.9
Often (Monthly)	45	11.4
Very often (Fortnightly)	27	6.8
Total	395	100.0

Note: = 4 - Very often (Fortnightly); 3 - Often (Monthly); 2 - Occasionally (Irregular); 1 - Never

The results in Table 23 showcase that most respondents, accounting for 74.9% ($n=296$), reported receiving training on climate adaptation practices occasionally. A significant proportion of the participants, 11.4%, indicated that they often received training on these matters every month. Moreover, a smaller yet notable group, comprising 6.8%,

reported a frequent training schedule, with sessions held fortnightly. An equivalent percentage of respondents noted that they had not received climate adaptation training during project implementation.

Overall, the most prevalent training frequency reported among the participants was occasional, suggesting that while efforts were made to provide training, it might need to be a more consistent and integral component of project implementation. This irregularity could potentially hinder the depth of understanding and the subsequent application of climate change adaptation practices among the farming community. On the other hand, the proportion of farmers who received training often or very often reflects a positive trend in terms of consistent exposure to climate adaptation education. This subset of farmers was more likely to integrate climate-resilient practices into their agricultural activities.

Notably, the current study's results, showcasing a higher percentage of farmers receiving occasional training, differ from some prior research that reported a more uniform and frequent training pattern. This discrepancy could indicate variations in project-based extension approaches across different contexts or regions (Gebre *et al.*, 2023). However, the similarity between the current study and previous research lies in the fact that even with occasional training, a notable percentage of farmers remain engaged in climate adaptation education. This parallel underscores the potential of project-based extension approaches to disseminate knowledge and effectively encourage sustainable practices adoption (Zhao *et al.*, 2022).

4.5.4 Association Between Effectiveness of Project-Based Approach and Adoption of Climate Change Adaptation Practices

The study sought to determine the association between the use of a project-based approach and the adoption of climate change adaptation practices. A Spearman's rank correlation analysis was conducted to quantify the strength and direction of the relationship between these variables. The resulting data is presented in Table 24, which displays the analysis's correlation coefficient and significance levels.

Table 24: Association between Project-Based Approach and Adoption of Climate Adaptation Practices

Spearman's Correlation	0.308**	1
Sig. (2-tailed)	0.01	-

**Correlation is Significant at 0.05

The spearman's correlation coefficient (ρ) was found to be 0.31, which indicates a positive association. The significance level (2-tailed) was $p < 0.05$, suggesting a highly significant correlation between the two variables.

The positive correlation coefficient of 0.31 suggests that, on average, as the utilization of the project-based extension approach increases, so does the adoption of climate change adaptation practices among the participants. This finding supports the notion that a project-based approach in planning and execution is effective in fostering the adoption of the adaptation technologies that enhance resilience to climate change. Previous research exploring similar relationships has often reported positive associations between innovative extension methods and the uptake of climate adaptation strategies (Galadima *et al.*, 2020). Therefore, the agreement between these findings strengthens the robustness of the evidence that project-based extension approaches play a crucial role in promoting climate resilience among farmers.

4.6 Adaptation to Climate Change Impacts

As part of the study's objective to understand how farmers were responding to reported climate change impacts, participants were asked to indicate whether they had taken any actions towards climate adaptation. The findings were then summarized using frequency and percentages, and the results are presented in Table 26.

Table 25: Action Towards Climate Adaptation Among Smallholder Farmers in Nyatike Sub-County

Climate adaptation	Male	Female	Percentage
Yes	177	96	69.11
No	78	44	30.89
Total	255	140	100.00

A significant majority of the respondents ($n = 273$, 69.11%) admitted to actively engaging in climate change adaptation measures. This proportion exceeds half of the

total sample size, highlighting the significant level of concern among farmers in dealing with the prevailing effects of climate change. This is in consonance with the findings of Islam *et al.* (2021) who concluded that there was a great concern and willingness among farmers to uptake adaptation strategies in Pahang coast of Malaysia. Notably, the response rate was higher among male ($n = 177$) participants compared to females ($n = 96$). This observation may be attributed to the fact that men tend to hold decision-making position within households, particularly concerning the adoption of new technologies and farming.

4.6.1 Adoption of Climate Adaptation Practices

Further the respondents were requested to indicate the adaptation practices that they have applied on their farms. By presenting the data in frequencies and percentages, the study can effectively showcase the prevalence of climate adaptation actions among the surveyed farmers, helping to identify trends and patterns in their responses.

Table 26: The Extent of Adoption of Climate Adaptation Technologies

Adaptation Technology	Frequency	Percentage (%)
Crop diversification	235	86.06
Planting early maturing crop varieties	208	76.19
Vaccination programs	76	19.24
Drought-tolerant crops	188	68.86
Heat tolerant breeds	107	27.59
Adjusting planting calendar	182	66.67
Agroforestry	164	60.07
Drought tolerant forage varieties	66	16.71
Mulching	139	50.92
Minimum tillage	85	31.14

Respondents who acknowledged acting towards climate adaptation were asked to indicate the adaptation technologies they have adopted, summary of these responses are presented in Table 26. Among the reported adaptation technologies aimed at mitigating the impacts of climate change on farming activities, crop diversification emerged as the most used technology (86.06%). Crop diversification involves cultivating different crops in a sequential manner on the same land. The primary objective is to reduce the risk of crop failure and enhance resilience against various environmental factors, including pests, diseases, and climate variability. By growing different crops with diverse growth requirements, susceptibility to pests, and harvest seasons, farmers can

minimize risks and optimize overall farm productivity. Additionally, crop diversification contributes to improving soil health, promoting biodiversity, and creating market opportunities by offering a variety of products.

Similarly, Aryal *et al.* (2020) concluded that farmers in South Asia have adopted crop diversification, specifically the combination of rice and wheat, to enhance resilience to climate change. This practice facilitates the control of pest outbreaks and reduces the risk of pathogen transmission, which are more likely to occur due to increased climate variability. This, in turn, helps to mitigate the impact of climatic stress on crop production, thereby buffering its effects. Moreover, in Ethiopia crop diversification, tree planting and off-farm activities are the most used adaptation technologies (Nega, 2022).

A significant majority of the survey respondents have adopted the use of early maturing crop varieties (76.19%) and drought-tolerant cultivars (68.86%). These varieties are specifically selected to mature within a specific time frame, making it easier to synchronize with the rainy season. Drought-tolerant cultivars are chosen for their ability to withstand higher temperatures and successfully complete their life cycle. Similar findings by Gebre *et al.* (2023) indicate that Kenyan farmers predominantly opt for drought and disease-resistant varieties as a key adaptation strategy. Additionally, Fahad and Wang (2018), reported that farmers have adopted change in crop type and variety, seed quality, and farm diversification in Pakistan. However, farmers highlighted the challenge of availability and access to these varieties, which hinders their adoption rates. Consequently, farmers sometimes have no choice but to rely on local species that are susceptible to environmental constraints.

Other adaptation techniques reported by the respondents include adjusting the planting calendar (66.67%), practicing agroforestry (60.07%), and mulching (50.92%). It's worth noting that mulching has received criticism for being expensive on a large scale, labour-intensive, and potentially causing temporary nutrient immobilization (SK *et al.*, 2020). However, minimum tillage (31.14%) was the least practiced adaptation technology in the study area. This coincides with the findings of Teklewold *et al.* (2019) that minimum tillage was only observed in 9% of the plots in Nile Basin of Ethiopia.

This could be due to lack of proper awareness of the practices and their benefits in restorations of soil properties. Farmers may lack proper knowledge about the advantages associated with minimum tillage, such as improved soil structure, reduced erosion, enhanced water retention, and increased soil organic matter. Without a clear understanding of these benefits, farmers may not view minimum tillage as a viable option for their agricultural practices.

Adoption of livestock adaptation practices was low compared to crop-related practices. Specifically, heat-tolerant breeds were adopted by 27.59% of respondents, showing a moderate level of uptake. Vaccination programs were used by 19.24%, and drought-tolerant forage varieties were the least adopted at 16.71%. These findings suggest that while some technologies are being utilized to improve livestock resilience, there is a lower prevalence of these practices, highlighting the need for enhanced promotion and support for livestock adaptation strategies. However, most farmers in Nyatike were majorly crop producers which was attributed to low pasture availability in the area.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Summary of the Findings

Objective one sought to assess climate change awareness and its impact on adopting adaptation practices as this would shape their thinking towards adoption of relevant adaptation practices. The study focused on gauging farmers' awareness levels and understanding their perception of changes in weather patterns over the past two decades. Farmers demonstrated varying degrees of awareness regarding climate parameters and their impacts. A substantial proportion acknowledged awareness of changing temperature ranges (86.6%) and extended periods of rainfall (68.8%), while an even higher percentage recognized the delays in rainy season onset leading to drought (96.73%) in Nyatike sub-county. These findings indicated a growing awareness of climate change parameters among farmers. Notably, respondents identified impacts like invasive weeds, pests and diseases proliferation, flooding, drought, and crop failure as expected outcomes of climate change, aligning with previous research. A statistical analysis indicated a clear relationship, as individuals with higher awareness levels were likelier to adopt climate adaptation practices. The results further demonstrated that a higher degree of awareness significantly influenced the adoption of these practices. Nevertheless, the influence of cognizance on reception was intricate since considerations including the accessibility of assets, admission to information, socio-financial situations, and imagined effectiveness of practices likewise contributed to the outcome.

In objective two, the study assessed the effectiveness of extension delivery channels in disseminating and promoting the adoption of climate change adaptation practices. The study aimed to determine the sources of information on climate adaptation practices and evaluate the impact of different extension channels on adopting these practices. It emerged that mass media channels, particularly radio (92.21%) and television (82.91%), were the farmers' primary sources of information on climate adaptation practices. While alternative media played a growing role, the address emphasized how conventional outlets retained a worthwhile impact in accessing a far-reaching viewership, specifically in more remote locales where prospects for engaging other kinds of media may remain restricted. On the other hand, interpersonal channels, such

as farmer-to-farmer interactions (89.45%) and public gatherings (82.66%), were also important sources of information for the farmers. These channels facilitated peer learning and knowledge-sharing within farming communities, making them powerful and effective means of disseminating information. Additionally, contact with extension agents, agricultural shows and farmer field schools provided valuable opportunities for farmers to learn and network, promoting innovation and knowledge transfer. Interestingly, the study analyzed the relationship between extension delivery channels and adopting adaptation practices. The study showed that both mass media and interpersonal channels positively and significantly impacted the adoption of these practices with interpersonal channels having a substantial influence in promoting behavioral changes among farmers.

It was found out in the study that the use of project-based extension approach was moderately effective in giving relevant and timely information on climate adaptation practices, creating awareness of climate change impacts, and follow-up visits. However, it was rated more effective in providing early warnings on climate trends. This suggests that personalized interactions and proactive measures, such as follow-up visits and early warnings, can significantly enhance adoption of climate change adaptation practices. In evaluating the project-based method's effectiveness, the research likewise considered the sufficiency of this approach. The participants rated the adequacy of the approach as moderate, indicating a reasonable level of perceived adequacy. Despite varying responses, it appeared from the diversity of perspectives that farmers may have deemed the methodology sufficiently contingent on their respective views and histories with the issue at hand. This highlights the importance of tailoring extension strategies to farmers' diverse needs and circumstances.

Ultimately, correlation between how successful the project-based approach was in adoption of adaptation practices unveiled a directly proportional relationship between the heightened implementation of project-focused outreach techniques and improved adoption of adaptation practices. This supports the notion that project-based approaches play a crucial role in promoting climate resilience among farmers. Moreover, most participants (69.11%) reported active engagement in climate adaptation measures. Crop diversification emerged as the most widely used strategy (86.06%), followed by

planting early maturing and drought-tolerant crop varieties. Other practices included adjusting planting calendars, agroforestry, mulching, and minimum tillage were also used as adaptation techniques. Through adopting these strategies, one was able to underscore the endeavors of farmers aiming to alleviate the impacts of climate change on agricultural output.

5.2 Conclusions

In conclusion, farmers level awareness of climate change impacts had a strong influence on adopting climate adaptation practices among smallholder farmers in the Nyatike sub-county, Kenya. Through intricate observations, most respondents showed a deep understanding of alterations in climate parameters across the past two decades. This awareness influenced their adoption of various climate adaptation practices to respond to the projected risks.

The study also highlighted the importance of different extension delivery channels in disseminating information and promoting the adopting of climate adaptation practices. In decades past, the limited options for information available to rural farmers mainly consisted of mass media outlets like the radio and television alongside interpersonal exchanges during informal conversations with peers or public congregations. These channels positively impact adopting adaptation practices, with interpersonal channels having a more substantial influence.

Furthermore, the project-based extension approach was moderately effective in providing relevant and timely information, creating awareness, and promoting adoption of climate adaptation practices. The approach was particularly effective in providing early warnings on climate trends. The study also emphasized the need for more consistent and tailored training to enhance farmers' understanding and application of climate change adaptation practices. Overall, the study concluded that enhancing climate change awareness, utilizing effective extension delivery channels, and implementing project-based extension approaches are crucial strategies for promoting climate adaptation practices among smallholder farmers in the Nyatike sub-county, Kenya, and improving their resilience to climate change impacts.

5.3 Recommendations

- i. By enhancing awareness and knowledge of climate change impacts, policymakers and agricultural extension services can better support farmers in adopting appropriate climate change practices, thereby improving their resilience and adaptive capacity in the face of climate variability.
- ii. Extensionists should endeavour to employ a blend of diverse communication channels to ensure timely and comprehensive information reaches a broad spectrum of audiences.
- iii. Extensionist and project developers should use a mix of extension approaches to improve the delivery of climate change adaptation practices information to farmers. This will ensure the relay of adequate, timely and diverse mix of adaptation information.

5.4 Suggestions for Future Research

- i. Understanding regional disparities in climate change awareness: The study found varying levels of climate change awareness among farmers in different regions, with South Africa having a lower awareness level than the study area. Future research could explore the factors contributing to these regional disparities and identify strategies to improve climate change education in regions with lower awareness levels.
- ii. Enhancing digital platforms for climate change information dissemination: The study revealed that mobile phones were perceived as the least effective channel for accessing climate adaptation information. Future research could explore ways to improve the effectiveness of digital platforms, such as mobile apps or text messaging services, in reaching and engaging farmers with relevant climate information.
- iii. Long-term impact of project-based approaches on climate resilience: While the study found a positive correlation between the effectiveness of the project-based approach and the adoption of adaptation practices, future research could investigate the long-term impact of such approaches on farmers' climate resilience. This could involve tracking changes in farmers' practices and outcomes over an extended period to assess the sustainability of behavioral changes and their contribution to overall climate resilience.

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APPENDICES

Appendix I: Introductory Letter

Dear Respondent,

I am Anyuor Samantha, a student at Chuka University, carrying out research *on the Effectiveness of Extension in the Adoption of Climate Change Adaptation Practices*. To fulfil partial requirement for the award of a master's degree in Agricultural Extension. This questionnaire is to collect data concerning the research from smallholder farmers in the Nyatike sub-county. Participation is voluntary and no remuneration is attached to this, your response is treasured for the success of the research. Filling out the questionnaire will require about 10 minutes of your time. I appeal to you to fill the questionnaire with honesty and integrity. The information will be treated with utmost confidentiality and will be useful in determining the impacts of climate change on rural productivity and promoting extension effectiveness in the agriculture sector. Thank you for agreeing to participate in this survey.

Yours sincerely,

Samantha Anyuor

Appendix II: Survey Questionnaire

Section A: Socio-Demographic Information

1. What is your Age (in years>18)? :.....
2. For how long have you stayed in this area (Years).....
3. Gender: Male [] Female []
4. Gender of the Household head: Male [] Female []
5. Education Level: No formal Education [] Primary [] Secondary []
Certificate [] Diploma [] Degree [] Postgraduate []
6. What crops do you grow on your farm (Select multiple) Maize [] Beans []
Sorghum [] Rice [] Sweet potatoes [] Other []
Other (specify).....
7. What is your employment status? Employed [] Self-employed [] Unemployed
[] Retired []
8. How long (in years) have you participated in farming?
9. What is the size of your farm (Acreage)

Section B: Awareness Level of Smallholder Farmers on Climate Change Impacts

10. Do you feel that the pattern of weather is generally changing?
[0] = YES [1] = NO
11. Are you aware of the listed climate change impacts? Kindly rate using the key
where; **5 = Highly Aware; 4 = Aware; 3 = Neutral; 2 = Unaware; 1 = Highly
Unaware**

Indicator	5	4	3	2	1
Increased Floods frequency					
Delayed rains					
Longer Drought period					
Extreme Temperature Ranges					
Pest and diseases infestations					
Increasing length of rainy season					
Increased cases of Invasive Weeds					

12. Based on your responses to question 11. How would you rate your level of
awareness of climate change impacts? Rate: Low [] Moderate [] High []
Very high []
13. Indicate the extent to which you agree with the following statements (climate
change impacts agriculture production in general). Use a Likert scale: **5 = Very
Great Extent; 4 = Great Extent; 3 = Some Extent; 2 = Little Extent; and 1= No
Extent at all.**

Effects of climate change on agriculture	5	4	3	2	1
Decreased soil fertility					
Drying of crops from the intense heat					
Floods destroying crop fields and domesticated animals					
Food insecurity					

Increased postharvest losses of crops					
Intensive growth of weeds					
The outbreak of pests and diseases for crops and livestock parasites					
Reduction in crop yield					
Soil erosion from runoff due to high-intensity rainfall					
Others specify:					

Section C: Selected Extension Dissemination Channels

14. I obtain access to information on climate change adaptation technologies through the following extension delivery channels? (Tick where applicable)

Channel		
Mass media	Radio	
	Television	
	Print media (newspaper, Brochures, etc.)	
	Phone (SMS, Calls, WhatsApp)	
	Internet (e-extension, YouTube, Facebook)	
Inter-personal channels	Agricultural shows/trade fairs	
	Farmer to farmer	
	Public gatherings (Chief's barazas, social events....)	
	Farmer field schools	
	Government Extension agents	
	NGO/Private Extension agents	

15. Kindly indicate how you agree with the following statements on the use of dissemination channels in promoting adoption of CAP. (Use a Likert scale: **5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree**)

Statement	5	4	3	2	1
Information from the extension agents on climate adaptation practices are authentic/genuine					
Information obtained through mass media on climate adaptation practices are more reliable					
Mass media extension channels are an effective in reaching a wide range of farmers					
Digital extension channels are an effective way of disseminating climate adaptation practices.					
Face-to-face interactions with extension agents facilitate faster adoption of CAP among farmers.					
Farmer-Farmer exchanges have positively impacted farmers adaptation to climate risks					
Knowledge acquired through radio programs are useful in meeting my adaptation needs					

16. How would you rate the overall effectiveness of the following extension methods used in the dissemination of climate change information?

5-Highly Effective 4-Effective 3-Moderate 2-Slightly Effective 1-Not Effective

Method	Highly effective	Effective	Moderately effective	Slightly effective	Not effective
Field days					
Home and farm visits					
Demonstrations					
Workshops/seminars					
Television					
Radio					
Phone/internet					
Exchange visits					
Farmer field school					

17. Kindly indicate your level of agreement with the following statements on the factors limiting the effectiveness of extension dissemination channels. (5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree)

Limitations	5	4	3	2	1
Low cooperation among farmers					
Inappropriate use of dissemination channels					
Low frequency of existing extension programs					
The incompetence of the extension personnel					
Low turnout for the meetings					
Low farmer-extension agent ratio					

Section D: Use of Project-Based Extension Approach

18. How would you describe the effectiveness of public extension in executing the following activities using the Project-Based Approach in climate change adaptation? (5-Highly Effective 4-Effective 3-Moderate 2-Slightly Effective 1-Not Effective)

Adaptation activity	Highly effective	Effective	Moderate	Slightly effective	Not effective
Creating awareness of climate change impacts					
Giving relevant and timely information on climate adaptation practices					
Follow up visits					
Early warnings on climate trends					

19. Kindly indicate how you agree with the following statements on the adequacy of the **Project-Based Approach**. Use a Likert scale of 5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; and 1 = Strongly Disagree.

Adequacy of Project-Based Approach	5	4	3	2	1
Conducting awareness meetings to sensitize farmers on climate change adaptation					
Conduct field days to publicize new and improved technologies of crops, and livestock that is drought and disease resistant.					
Conducting demonstrations to farmers on new knowledge and skills in climate change adaptation practices					
Training farmers on proper practices to increase shelf life and reduce postharvest losses.					
Linking farmers to relevant research institutions for on-farm adaptive research on smart practices for climate change adaptation.					

20. Kindly tick on how often you are trained on matters related to climate adaptation during project implementation.

[4] = Very often (Fortnightly); [3] = Often (Monthly); [2] = Occasionally (Irregular)

[1] = Never

Section D: Climate Adaptation Practices

21. Have you ever taken any action out of concern for climate change?

[0] = YES [1] = NO

22. If yes, which of the following adaptation practices disseminated through extension projects do you practice on your farm? (Tick where applicable).

Practice	
Use of early maturing crop varieties	
Agroforestry	
Intercropping	
Mulching	
Adjusting planting calendar	
Planting drought-tolerant crops	
Minimum tillage	
Specify any other	

23. Indicate the extent to which you apply the following practices in your farm? (5-Very High 4-High 3-Low 2-Very Low 1-Not at all)

Practice	Very High	High	Low	Very Low	Not at all
Use of early maturing crop varieties					
Agroforestry					
Crop diversification					
Intercropping					
Intensified irrigation					
Adjusting planting calendar					
Planting drought-tolerant crops					
Processing crops produce to reduce pH losses					

24. Kindly indicate the degree to which you agree with the following statements on the likely constraints to the adoption of climate adaptation practices. (**5 = Strongly Agree; 4 = Agree; 3 = Not Aware; 2 = Disagree; and 1 = Strongly Disagree**).

Constraints	5	4	3	2	1
Lack of credit					
Shortage of labor					
Inadequate access to timely information					
Farmer resistance to change					
Lack of information about the weather					
Lack of knowledge and skills to implement the practices					

THANK YOU

Appendix III: Map of the Study Area



Appendix IV: NACCOSTI Research Permit


REPUBLIC OF KENYA
 National Commission for Science, Technology and Innovation
Ref No: 544603


NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
 Date of Issue: 22/November/2023

RESEARCH LICENSE



This is to Certify that Miss. SAMANTHA AKOTH ANYUOR of Chuka University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Migori on the topic: EFFECTIVENESS OF AGRICULTURAL EXTENSION IN ADOPTION OF CLIMATE CHANGE ADAPTATION TECHNOLOGIES AMONG FARMERS IN NYATIKE SUB-COUNTY, KENYA for the period ending : 22/November/2024.

License No: NACOSTI/P/23/31343

Applicant Identification Number: 544603


Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

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Appendix V: Chuka University Ethical Review Committee Approval



CHUKA UNIVERSITY INSTITUTIONAL ETHICS REVIEW COMMITTEE

Telephones: 020-2310512/18

Direct Line: 0772894438

Email: info@chuka.ac.ke,

P. O. Box 109-60400, Chuka

Website: www.chuka.ac.ke

14th July, 2023

REF: CUIERC/ NACOSTI/411

TO: Samantha Akoth Anyuor

RE: Effectiveness of Agricultural Extension in Adoption of Climate Change Adaptation Technologies Among Farmers in Nyatike Sub-County, Kenya

This is to inform you that *Chuka University IERC* has reviewed and approved your above research proposal. Your application approval number is *NACOSTI/NBC/AC-0812*. The approval period is 14th July, 2023 – 14th July, 2024.

This approval is subject to compliance with the following requirements;

- i. Only approved documents including (informed consents, study instruments, MTA) will be used
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *Chuka University IERC*.
- iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Chuka University IERC* within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to *Chuka University IERC* within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days upon completion of the study to *Chuka University IERC*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://oris.nacosti.go.ke> and also obtain other clearances needed.

Yours sincerely

Dr. Benjamin Kanga
SECRETARY

Appendix VI: Chuka University BPS Authorization Letter



Knowledge is Wealth (*Sapientia divitia est*) Akili ni Mali

**OFFICE OF THE DIRECTOR
BOARD OF POSTGRADUATE STUDIES**

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Website: www.chuka.ac.ke

REF: NM27/38553/18

13th October, 2023

**Director
National Commission for Science Technology and Innovation
Off Waiyaki Way, Upper Kabete
P O Box 30623, 00100
Nairobi.**



Dear Sir / Madam,

SAMANTHA AKOTH ANYUOR

The above-named person is a *bona fide* student of Chuka University pursuing MSC in Agricultural Extension proposal titled: **Effectiveness of Agricultural Extension in Adoption of Climate Change Adaptation Technologies Among Farmers in Nyatike Sub-County, Kenya**

Ms. Akoth has defended at the Faculty level and is now expected to conduct research. Any assistance accorded will be highly appreciated

Yours sincerely,


Prof. Moses Muraya, Ph.D.
13 OCT 2023

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