KSh. 3000/-

SMALLHOLDER FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE EFFECTS IN THE HIRAN REGION, SOMALIA

BY

ABDIWALI ABDULLE ODAWA (*BSC. AGRICULTURE*)

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ENVIRONMENTAL SCIENCE (ENVIRONMENTAL SCIENCE) IN THE SCHOOL OF AGRICULTURE AND ENVIRONMENTAL SCIENCES OF KENYATTA UNIVERSITY

SEPTEMBER 2024

DECLARATION

Declaration by Candidate:

This thesis is my original work and has not been presented for a degree at any other university.

Abdiwali Abdulle Odawa
Reg. No.: N50F/27939/2019

.... Signature .... Date 25/09/2024

Supervisors:

We, the undersigned, confirm that the work presented in this thesis was undertaken by the student under our supervision and with our approval as the University supervisors.

Prof. Monicah Mucheru-Muna
Department of Environmental Sciences and Education

.... Signature .... Date 25/09/2024

Dr. Benson Kamau Mburu
Department of Environmental Sciences and Education

.... Signature .... Date 25/9/2024

DEDICATION

This work is devoted to my loving mother and grandmother, for their unconditional support and enthusiastic involvement in my whole educational career, and to all my brothers and sisters for their sponsorship of my education.

ACKNOWLEDGEMENT

All glory be to **Allah**, the Almighty for his generosity in allowing me to complete this work. I also thank my supervisors, **Prof. Monicah Mucheru-Muna** and **Dr. Benson Kamau Mburu**, whose efforts and direction enabled me to complete the thesis. I will always be indebted to them for their constant support and consultation from the beginning of my proposal until the writing of my thesis. I'm thankful to my beautiful family for their encouragement and support in assisting me in accelerating progress. I appreciate the cooperation and contribution of the community in the region, especially the respondents, during the data collection process.

ABSTRACT

Climate change remains a key barrier to achieving the Sustainable Development Goals in Somalia, concerning food security. It seriously and directly endangers national food security by compromising agricultural production. Climate change adaptation can diminish many of the consequences of climate change while maximizing its benefits. Yet, farmers' perspectives about these effects of the changing climate, adaptation strategies, and the accessibility of information about climatic conditions are not addressed or covered in Somalia, which is crucial when planning policy interventions. This study's objectives were to; (i) assess how socioeconomic factors influence smallholder farmers' perceptions of climate change effects, (ii) analyze the factors influencing the adaptation practices adopted by the farmers, and (iii) evaluate the factors that influence accessing climate information and the information sources for the farmers. Quantitative research designs used both descriptive statistics and econometric techniques. From August 2022 to December 2022, 222 smallholder farmers were surveyed using a questionnaire. Using SPSS and STATA, the study used descriptive statistics, probit regression, and binary logistic regression models. The probit regression model showed that gender, family size, farm size, and communication gadgets significantly influenced farmers' perception of climate change. The binary logistic regression results showed that farmers' different adaptation measures in the region were influenced by age, family size, marital status, non-farm income, access to credits, access to extension, and, support from extension agencies. Binary logistic regression results also showed that distance to the market, education level, gender, marital status, farm size, and support from these agencies had a significant association with farmers' climate information access. Further, the sources of climate information were significantly influenced by their age, access to credits, possession of communication devices, and support from agricultural extension agents, NGOs, and international agencies. Socioeconomic and institutional factors such as gender, marital status, size of family, farm size, access to communication devices, age, non-farm income, education status, access to credits, access to agricultural advisory services, and support from various agencies (including NGOs and international organizations) significantly influenced farmers perception, adaptation measures, climate information access and sources in Hiran region. The federal/State institutions and local/international agencies are recommended to develop adaptation programs that consider the specific demographic characteristics of smallholder farmers, create gender-sensitive agricultural programs and inclusive policies, improve access to communication devices, and provide targeted training.

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

CIS	Climate Information Services
CSA	Climate Smart Agriculture
FAO	Food and Agricultural Organization
FGS	Federal Government of Somalia
GDP	Gross Domestic Product
HA	Hectare
IPCC	Intergovernmental Panel on Climate Change
NAPA	National Adaptation Programme of Action
NCCP	National Climate Change Policy
NEP	National Environment Policy
RRF	Resilience and Recovery Framework
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNPF	United Nations Population Fund
WB	World Bank

DEFINITION OF TERMS

Perception: This is the method of obtaining data and incentives from our environment and translating this information into psychological responses (Van den Ban *et al.*, 2000).

Adaptation: These are changes in environmental and human systems concerning climatic stimuli and their impacts that help farmers cope with the climate crisis and unpredictability, mitigating possible damages, coping with negative effects, and taking advantage of the available opportunities (IPCC, 2018).

Climate change: Shift in climate factors throughout time due to natural forces and human influence on the environment (IPCC, 2007).

Climate information: It is mainly consisting of forecasts and alerts about upcoming weather conditions (Debra, 2021).

Smallholder farmers: Smallholder farmers are defined as those who cultivate a limited plot of land, planting food crops and occasionally small kinds of cash crops (Notenbaert *et al.,* 2014).

Vulnerability: It is a result of a system's sensitivity, adaptive capability, and the kind, amount, and pace of climatic fluctuation to which it is exposed (IPCC, 2001)

Socio-economic factors: Refers to the characteristics related to human relationships, and the source and level of livelihood such as age, farm size, income, education, family size, and land ownership (Odari, 2018).

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Worldwide climatic mean temperature variation has been recorded, and much more increases are anticipated in the foreseeable future (IPCC, 2007). Most experts predicted a 2–4 °C rise in global temperatures, and potentially much more (Meinshausen *et al.*, 2009). Furthermore, Nicholls & Cazenave (2010) also predicted a 1 m sea level rise by 2050. In Southeast Asia, the average temperature has mounted every decade since 1960 (Amit, 2018). Countries such as Vietnam and Thailand are among the ten nations damaged by climate change during the last twenty years (Eckstein *et al.,* 2018). Due to temperature rises and rainfall decreases, Africa is among the top regions that could be seriously harmed by climate change (IPCC, 2014). By the year 2100, the temperatures in Africa may escalate quicker than their counterparts around the globe, with the rise reaching 4 °C (Niang *et al.,* 2014). The Horn of Africa region has experienced increases in extreme temperatures during the past half-century (IPCC, 2007). Additionally, the World Climate Research Programme (2012) anticipated a gradual temperature increase for Somalia, reaching a maximum of 3.2 °C by 2080.

Almost all African countries rely on agriculture to ensure food security, maintain a healthy economy, and alleviate poverty, since agriculture, which is dependent on rain, comprises 30% of their GDP as well as employs approximately 70% of the continent's inhabitants (Asafu-Adjaye, 2014). Climate change has already harmed numerous economic sectors in many countries, notably agriculture (Ahsan *et al.*, 2020). Furthermore, Ramirez-Villegas & Thornton (2015) opined that variations in weather patterns are anticipated to shift agricultural production zones worldwide. Sub-Saharan Africa (SSA) remains more seriously unprotected from the detrimental consequences of the climate crisis than the other regions of the world (Esham & Garforth, 2013). This is due to their lack of adaptability and poverty (Bagamba *et al.*, 2012).

Agriculture is important in Somalia's economy, accounting for around 75% of GDP and 93% of total export revenues, respectively (FAO & World Bank, 2018). However, different factors, including political, economic, and environmental constraints, hinder the development of a successful agriculture sector (Warsame *et al.,* 2021). Moreover, environmental concerns, particularly climate change, are an important obstacle in Somalia, which is among the most susceptible nations globally to the hazards of climate variation and/or change (Carty, 2017). Additionally, according to FAO & the World Bank (2018), climate-related changes in temperature, along with precipitation trends, contribute to an unstable situation for the nation, which already faces significant economic, social, and environmental vulnerability.

Based on extensive discussions with communities throughout Somalia, the National Adaptation Action Programs of Somalia have identified drought, significant flooding, rising temperatures, and strong winds among Somalia's major climate hazards (Federal Government of Somalia, 2013). According to FAO & the World Bank (2018), Somalia suffered a $72 million monetary loss on its primary four crops as an outcome of the 2017 drought: corn and sorghum ($35 million), cowpeas ($9 million), and sesame ($28 million). Flooding reduces agricultural productivity, damages property, displaces communities, and sometimes kills vulnerable people. It is common due to downpours that overrun existing rivers during wet seasons (Warsame *et al.,* 2021). In 2019, floods took numerous lives, displaced 412,000 people, and caused significant crop damage in Somalia (GIEWS, 2020). Furthermore, Somalia is subjected to high winds, which degrade soil fertility, affecting the agricultural output (Waaben *et al.,* 2020). Due to existing circumstances, Somalia's adaptation policies and regulations to moderate the adverse consequences of the climate crisis in agriculture are inadequate (Warsame *et al.,* 2021). This could be attributable to a shortage of substantial empirical research that investigates the association between agriculture and climate variation in addition to weak governance institutions (World Bank & FAO, 2018).

Due to more than 20 years of civil conflict, political unrest, and terrorist attacks, Somalia lacked the means and ability to effectively combat the detrimental consequences of the climate crisis. In addition, the country's natural resource-related conflicts and the difficulties faced by the overwhelming majority of its displaced citizens from their residents were made worse by the changing climate (Federal Government of Somalia, 2022). Even so, despite its ongoing fragility, Somalia has made great strides in the last ten years toward stabilizing many areas of the nation and establishing government institutions. These include the establishment of political, social, environmental, and economic systems that point to a significant advancement (Federal Government of Somalia, 2022).

The Somali government and its allies implemented several measures to combat the challenges posed by climate change. The National Adaptation Programme of Action (NAPA) was the first national agreement in Somalia to address the critical need for adaptation to climate change. The Federal Government of Somalia (2013) focuses on raising community awareness, improving monitoring capacities, and assisting vulnerable groups. It also provides a platform for incorporating climate adaptation into development planning. Additionally, Somalia's Resilience and Recovery Framework (RRF) addresses the long-term effects of drought by promoting resilience and disaster preparedness, strengthening government capacity, diversifying livelihoods, and improving natural resource management to break the cycle of vulnerability to climate shocks (Federal Government of Somalia, 2018).

According to the Federal Government of Somalia (2019), the National Environment Policy (NEP) emphasizes the need for mitigation and adaptation strategies, highlighting the need for clean technology, biodiversity protection, and reduced greenhouse gas emissions. It also recognizes that climate crises and disaster management are critical issues that must be addressed. The policy also highlights Somalia's limited capacity for adaptation and the necessity of taking action to address climate-related. Furthermore, the National Climate Change Policy 2020 (NCCP) that emphasis's the significance of aligning national policies with international climate agreements and supports improved climate change management through collaboration with development partners. The NCCP also focuses on improving sectoral strategies and ensuring coordination between national and sub-national governments. It further provides strategic direction for climate adaptation and mitigation (Federal Government of Somalia, 2020).

Adaptation to the climate crisis can significantly minimize climate change's harmful effects while maximizing its benefits (Smit & Pilifosova, 2003). Belay *et al.* (2017), however, argued that the uptake of these strategies is a function of several socioeconomic factors of the smallholder farmers. This implies that successful adaptation by smallholder farmers, particularly in tropical regions, will be necessary to adjust to and deal with the effects of the changing climate (Mwaniki, 2016). On the other hand, using climate and weather information can assist farmers minimize the harmful consequences of climate hazards on agricultural productivity (Sonny *et al.*, 2020). Additionally, according to Viola *et al.* (2014), the formulation of appropriate adaptation methods for responding to severe climate change events will be determined by knowledge of climate information. However, farmers' attempts to increase agricultural production have been hindered due to a lack of appropriate information (Mwalukasa, 2013). Improving farmers' access to suitable climate information services can help them produce more crops and meet their agricultural information demands (Mtega, 2012).

1.2 Problem Statement

Somalia's economy and food security are highly reliant on agriculture. It not only provides the necessary sustenance for the majority population but also generates income through the sale of crops and the creation of labor opportunities in the agricultural sector. Domestic production can meet approximately half of the grain requirements of Somalia's population (Boitt *et al.*, 2018). This pinpoints the rationale of agriculture in Somalia and its potential to drive economic growth and development. However, Somalia has been facing constant natural calamities and a degraded natural resource base leading to crop yield declines (Jama *et al.*, 2020). For example, between 1980 and 2017, Somalia experienced eight significant weather incidents such as droughts and floods (1982–83, 1991–92, 1994–95, 1997–98, 2002–03, 2006–07, 2009–11, and 2015–17) (FAOSTAT & FSNAU, 2017). Since there are not many other options a large number of Somalis have also resorted to unsustainable resource exploitation, increasing the nation's sensitivity and susceptibility to future climatic crises (World Bank & FAO, 2018).

Climate change adaptation involves taking actions to lessen the harmful consequences of climate emergencies and help communities adapt. With inadequate adaptation mechanisms, the consequences of climate crisis can have severe repercussions on communities, businesses, and ecosystems (Gbetibouo, 2009). Therefore, any effective adaptation policy must consider farmers' understanding of the climate crisis, different coping techniques, and the factors prompting such perceptions and adaptation (Fosu-Mensah *et al.*, 2012). Moreover, having three to six months' notice of timely and reliable climatic information services (CIS) is a precondition for agricultural productivity and risk reduction (Jones *et al.*, 2000). Due to these circumstances, however, this study assessed adaptation methods among smallholder farmers in the Hiran region, Somalia.

1.3 Research Questions

This study was conceived to respond to the following questions:

1. How do the socioeconomic characteristics of farmers in the Hiran region of Somalia, influence their perception of climate change?
2. What are the factors influencing the adaptation methods to the risk of climate change among the farmers' Hiran region of Somalia?
3. Which factors influence the access to climate information and the information sources of the farmers in the Hiran region of Somalia?

1.4 Research Objectives

This study's objectives were:

1. To assess how socioeconomic factors, influence smallholder farmers' perceptions of climate change effects in Hiran, Somalia.
2. To evaluate the factors prompting the adaptation mechanisms by farmers in Hiran, Somalia, to climate change effects.
3. To analyze the factors that determine climate information access and the information sources of the farmers in Hiran, Somalia.

1.5 Research Hypotheses

The hypotheses guiding this study were:

1. There is a significant association between the perceptions of farmers on the effects of a changing climate and farmer socioeconomic characteristics.
2. There is a positive correlation between institutional factors (e.g. access to credits, or agricultural extension services) and how farmers adapt to climate change.
3. The level of education of smallholder farmers influences their climate information access significantly.

1.6 Significance of the Study

The study outcomes could make it possible for policymakers, professionals, researchers, and the federal government of Somalia to develop policies and tools that will strengthen farmers' potential to adapt to climate emergencies more effectively, reduce poverty, increase food security, as well as improve their livelihood. The findings could also lead to the necessary coordination between climate change information sources, skilled extension agents, NGOs, and the farming community in the Hiran region to close the climate change information gap. This will lead farmers to access timely and reliable climate information, which is a precondition for agricultural productivity and risk reduction. The study outcome will also contribute significant facts about the farming community's perspectives toward climate variation, their coping methods, together with their climate information access and sources. These findings may be used by other scholars as a literature review or as a basis for further research.

1.7 Justification of the Study

Climate change has contributed to instability in Somalia, which is compounded by several socioeconomic issues, including poverty, inadequate infrastructure, a lack of funding and technology, and weak institutions. The nation has already seen several climate disasters; the most recent of which was the flash floods in the Hiran districts, which caused many to be displaced and lost their lives. Many locals, especially those who live in rural communities, have seen the change in rainy seasons owing to unpredictable rainfall, which has an impact on agricultural practices and livelihood. Additionally, the nation has seen numerous, extended droughts that have severely impacted agriculture and livestock production. These repercussions result in food insecurity, starvation, malnutrition, displacement, fatalities, etc.

Due to smallholder farmers' high susceptibility to the adverse consequences of climate crises in the Hiran region, which gravely jeopardize livelihoods, food security, and agricultural productivity, this study is crucial since smallholder farmers are fundamental to the regional economy and food supply, it is essential to comprehend and record their adaptation techniques, their perception to the effects of changing climate and their access to climate information as well as their information sources. This study will help policymakers and development organizations create focused interventions to improve resilience and sustainable agricultural practices in the face of current and upcoming climate challenges. It will also offer insightful information about how these farmers deal with and adapt to climate change.

1.8 Conceptual Framework

Adaptation strategies to the impacts of climate change have the potential to significantly lower the unfavorable effects of climate change by improving households' capability to adjust to changes in climate, minimizing potential impacts, and assisting farmers in allocating resources to the negative effects (IPCC, 2001). In developing policies and programs that promote successful adaptation in agriculture, a deeper knowledge of stakeholders' attitudes to changes in climate and their adaptation techniques is required (Belay *et al.*, 2017). Moreover, accessing agricultural information is regarded as a critical constituent of modern agriculture and for ensuring more agricultural production (Rehman *et al.*, 2013). It is essential to the progress of the agricultural sector generally (Oladel, 2006).

The conceptual framework illustrates that communities must first understand climate change before beginning any kind of adaptation. In other words, the initial phase of initiating climate change adaptation measures involves acknowledging the existence of climate hazards. Furthermore, access to climate information and information sources is also a pre-condition and critical factor for effective climate change adaptation for farmers.

Farmer's adaptation, perception, and access to climate information are influenced by both internal and external factors. Internal factor involves socioeconomic and demographic factors: These may include age, gender, education level, farm income, non-form income, and farming system. External farmers involve Institutional factors such as access to agricultural extension services, access to credits, support from agricultural extension, and distance to the nearest market. The level of comprehension of the effects of changing climatic circumstances by farmers, in combination with the availability of climate information, can enhance their adaptation capacity, potentially resulting in increased agricultural output. This increased productivity can further bolster the capacity of a farmer to cope with the effects of changing weather conditions.

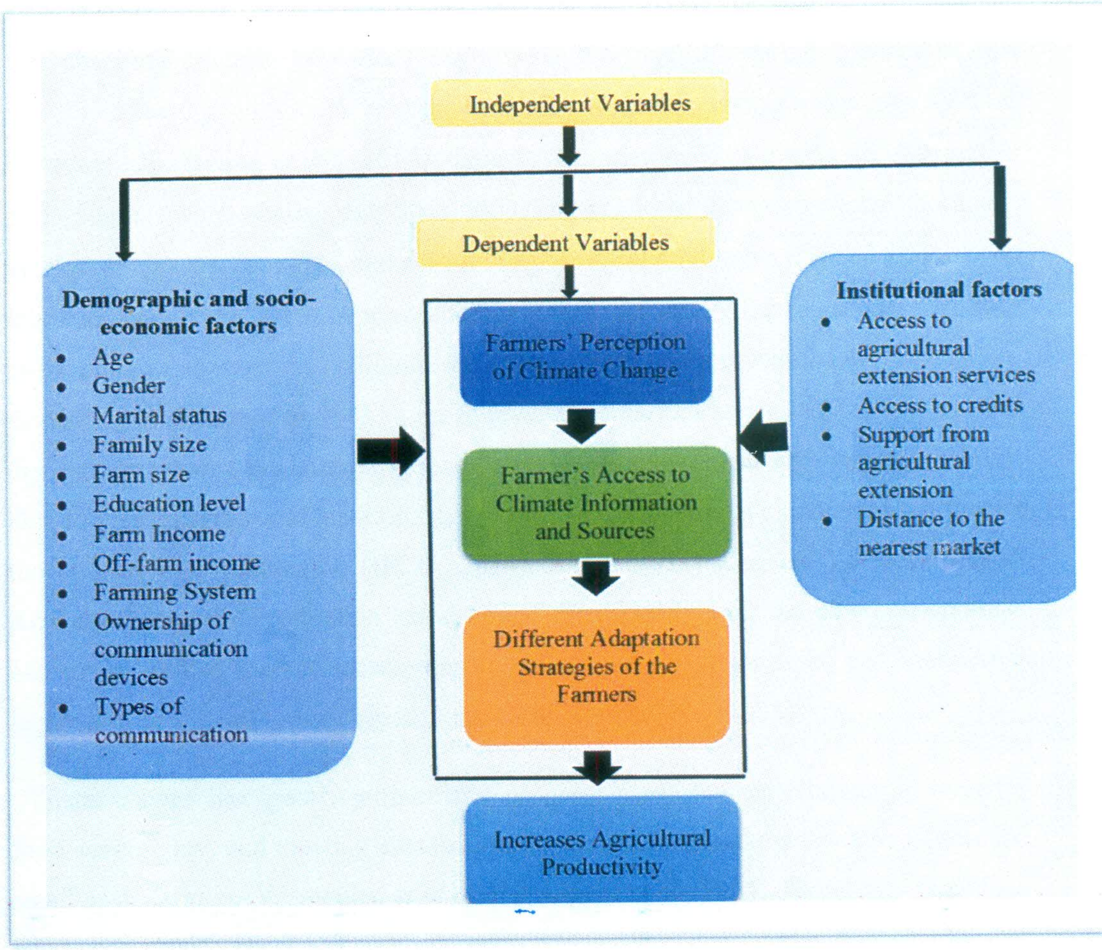

Figure 1. 1: Conceptual Framework (source: adapted from Hirpha, 2018)

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview

The changing climatic conditions are among the biggest weather hazards of this century, affecting all global economies and threatening people's incomes (Ali & Erenstein, 2017; Xie *et al.,* 2018). Due to the continued warming of the earth's atmosphere, severe weather extremes, including sea level increases, water shortages, melting of glaciers, droughts, and a drop in agricultural productivity, may become even more common (Qin, 2015). Approximately 55% of Africa's GDP relies on agriculture as the pillar of its economy (Alliance for a Green Revolution in Africa (AGRA), 2017). According to Edame *et al.* (2011), most developing nations are situated in tropical and dry regions, which have been experiencing temperature increases and scarcity of water. Due to their geographical location, these countries face serious climate-related threats that impact crop production (IPCC, 2014). Kotir (2011) asserted that sub-Saharan Africa's agricultural production has dropped dramatically over the past half-century. Moreover, limited market access, unsuitable topography, poor soils, and ineffective legislation contribute to poor agriculture productivity (FAO, 2008).

Climate change has greatly jeopardized progress made toward eliminating poverty, food sovereignty, and meeting sustainable development goals and has also threatened small-scale farmers (Vermeulen *et al.,* 2012; Lipper *et al.,* 2014). Moreover, according to Morton (2007), there are approximately 475 million smallholder farmers globally who grow an average of just under 2 hectares of farms. Lowder *et al.* (2016) and Cohn *et al.* (2017) emphasize that this group often faces poverty, food insecurity, and precarious living conditions. Furthermore, smallholder farmers remain susceptible to climatic breakdown since most of them are reliant on rainfall for agricultural production, cultivate on negligible lands, and are without access to technology or financial assistance that would allow farmers to participate in further climate-smart farming activities (Morton, 2007).

Climate change has significantly decreased overall crop yields by 1–5% globally every decade over the past 3 decades, with significant anticipated adverse effects on tropical grains like corn and rice (IPCC, 2014). Furthermore, Challinor *et al.* (2014) reported growing evidence that agricultural production would drop globally, even at lower (+2 °C) warming levels, particularly in tropical areas. Additionally, climate emergency is predicted to cause a decline in the production of maize by 5%, sorghum yields by 14.5%, and millet yields by 9.6% in Africa during this century (Knox *et al.*, 2012). Rosenzweig *et al.* (2013) also noted that, in the best-case scenario, total African maize production would fall by the end of this century from 42 million tons annually to 37 million tons annually (a 12% reduction), while in the worst-case scenario, production would fall by 40% reduction if no adaptation measures were undertaken.

2.2 Adaptation Strategies of the Farmers

The Paris Agreement of 2015 appreciates the rationale of adaptation in reinforcing resilience and reducing vulnerabilities to climate crises to contribute to sustainable development (UNFCCC, 2015). Farming remains the primary cause of income for many rural communities in SSA, adjusting to the climate crisis consequences plays a critical part in enhancing bounciness within the agricultural value chain, protecting incomes, and reducing susceptibilities associated with the lack of food security due to the changing climatic conditions (Sultan & Gaetani, 2016).

Ndambiri *et al.* (2014) noted that 85% of the rural subsistence farmers from Kyuso Sub-county, Kenya, practice climate change coping strategies. These farmers employed an array of adaption strategies, with 64% of the respondents growing alternative crops and altering the cultivation land area. Switching to agricultural activities (9%) and practicing irrigation (8%) were the least common adaptation techniques used by farmers. Similarly, Ojo & Baiyegunhi (2020) found that 52% of smallholder farmers in southwest Nigeria implemented at least one climate change adaptation technique for dealing with climate change impacts. Furthermore, Asadu *et al.* (2018) noticed that cucumber producers in Nigeria utilize organic manure, rapid weeding, crop diversification, early harvesting, early planting crops, and crop rotation. Planting early maturing crops, using irrigation techniques, minimizing soil tillage, and avoiding bush burning are some of the other options farmers adopt.

Regardless of farmers' climate change knowledge in Ghana, 44% of them had taken steps to adapt to climate hazard effects (Fosu-Mensah *et al.*, 2012). Crop diversification and altering crop planting schedules have been regarded as the two most important adaptation strategies in a warm environment. Moreover, Harvey *et al.* (2018) indicated that even though most coffee and basic cereal producers in Central America believed climate change was occurring and observed serious effects on their fields and livelihoods, fewer than half had substantially adapted farm management techniques to avoid climate change effects. Other adoption strategies undertaken by farmers for fighting against climate change include income diversification, planting at the beginning of rains, planting early maturing seed, planting trees, using a different tillage system, storing food, digging drainage channels, changing their planting schedule, using drought-resistant varieties, or disease and pest resistance varieties, and increased application of pesticides and fungicides, among others (Okonya *et al.*, 2013; Fahad & Wang, 2018).

The household heads' gender, family heads' marital status, family size, length of farming experience, the quantity of cultivated land, market distance, and revenue were significant factors that determined smallholder farmers' adaptation strategies (Atube *et al.*, 2021). Furthermore, according to Deressa *et al.* (2009), social capital (the total relatives in an area and their extension among farmers) also helps with coping with climate change effects. Along the same lines, accessing agricultural extension services, loans, as well as soil and water conservation are all important factors for the adaptation to climate hazards (Fosu-Mensah *et al.*, 2012). Elsewhere Ndambiri *et al.* (2014), Alem *et al.* (2016), and Belay *et al.* (2017) noted that changes in temperature and precipitation, local agroecology, livestock production, availability to markets, climate information, and non-farm revenue are all elements influencing the small-scale farmers adaptation strategies to the changing climate conditions. Conversely, Fosu-Mensah *et al.* (2012) and Ndambiri *et al.* (2014) indicated that schooling level, gender, size of the farm, and number of years of being a farmer had no positive effect on their adaptation measures.

2.3 Constraints Associated with Adaptation to Climate Change by Farmers

Adopting the consequences of the rapidly changing climate faces several challenges including inadequate labor, uncertain land tenure, limited access to market for their produce, poverty, asset deprivation, insufficient water resources, scarce credit options, poor knowledge, and information dissemination, and lack of government support (Fahad & Wang, 2018). The same difficulties were mentioned in the Nigerian context by Sofoluwe *et al.* (2011), who identified lack of information, capital, labor, land, and irrigation potential as the five primary constraints inhibiting adaptation efforts. Furthermore, Benhin, (2006) and Asadu *et al.* (2018) also reported that insufficient processing facilities, inadequate accessibility to financing, insufficient access to storage services, high labor demand, limited income, insufficient market facilities, communal systems of land ownership, irrigation, and inadequate access to pesticides, disease-tolerant cultivars are the main bottlenecks of coping to climate change among farmers.

Other reported documented hindrances e.g., in Juana *et al.* (2013) and Balew *et al.* (2014), include restricted access to markets, limited education, lack of credit facilities, poor health, insecure land rights, gender issues, and limited access to input markets. Strengthening individuals' capability to react to climate change could improve their capability to cope with the current climatic hazards (Smit & Wandel, 2006; Wiid & Ziervogel, 2012). Therefore, to understand what influences farmers' decisions and responses to deal with the climate crises' consequences, it is necessary to investigate the barriers they confront (Bryan *et al.*, 2012).

2.4 Farmers' Perceptions of Climate Change

Perception of climate change is complicated as it includes a variety of mental components such as familiarity, philosophies, attitudes, and worries regarding whether and in what way climate is varying (Whitmarsh & Capstick, 2018). Individual qualities, experience, information received, and the geo-cultural environments of people determine their perception (Van der Linden, 2015; Whitmarsh & Capstick, 2018). The fluctuation of local weather poses a challenge when distinguishing between ordinary short-term variants and the signs of a change in climate conditions (Hansen *et al.*, 2012). As opined by Lehner & Stocker (2015), short-range variations are more apparent than long-standing tendencies and can impact climate change perception. According to Simelton *et al.* (2013), it is crucial to appreciate that perception is subjective, and individuals in a similar location may construct and develop perceptions of climate change, despite sharing weather patterns.

Climate change awareness assists farmers in planning their production activities and reduces the hazards and fears associated with farming (Alem *et al.*, 2016). Moreover, perceptions of farmers to long-term changes in climate have an essential component in their adaptation process and represent a key factor in determining their behavior (Adger *et al.*, 2009).

According to Harvey *et al.* (2018), 95% of the interviewed farmers in Central America had noticed climate change, and they had previously experienced the consequences of increasing temperatures, erratic precipitation, the incidence of weather extremes, disease and pest incidence, income generation, and, in certain situations, food security. Similarly, Alem *et al.* (2016) found that 82% of the farm households interviewed in Eastern Ethiopia, based on their individual experiences, had witnessed at least one kind of climate emergency throughout the last twenty years. Likewise, in Bangladesh, more than 87% of the farming communities in the coastal areas have experienced either a rising trend in temperatures, droughts, floods, cyclones, salinity levels, or decreased rainfall (Uddin *et al.,* (2017). In contrast, 57% of rural farmers in Enugu State, Nigeria, have a moderate understanding of climate change effects, while another 41% have little awareness (Okoro *et al.,*2016).

According to Asrat & Simane (2018), farmers' perceptions of climate hazards were related to educational attainment, household-head age, temperature/precipitation fluctuations, farming exposure, climate information, and the length of food scarcity. Education level, family size, family income, farming experience, and training obtained significantly influenced farmer's perception (Uddin *et al.,* 2017). Elsewhere, family heads' age, education, farming experience, family size, accessibility to irrigation, a nearby market, and local agroecology were all important factors in influencing farmers' perceptions of climate hazards (Ndambiri *et al.*, 2014). Young age and highly educated household heads in Chile indicated improved perceptions of climate hazards relative to the old or uneducated group (Roco *et al.,* 2015). Additionally, Deressa *et al.* (2008) found that family wealth measured by farm and non-farm income together with animal holdings—improved the probability that farmers will recognize the fact that climate change is happening. Women exhibit lower levels of engagement in agricultural activities and decision-making processes in contrast to their counterparts who are men (Funatsu *et al.,* 2019; Orduño *et al.,* 2019; Altea, 2020). As a result, women may be less aware of climate emergencies, and in certain cases, they may not recognize climate change as an anthropogenic phenomenon (Funatsu *et al.,* 2019; Altea, 2020).

Agroecological conditions can also have a significant influence on climate crisis perception (Karki *et al.*, 2020). For instance, farmers residing in dry parts, where precipitation is consistently unpredictable, display a superior level of awareness regarding climate hazards relative to those in regions with abundant irrigation infrastructure (Roco *et al.,* 2015). Elsewhere in Brazil, both rainforest and shrubland farmers exhibit a lower level of awareness regarding the implications of climate change (De Matos Carlos *et al.,* 2020). The altitude of the farming land is one factor that appears to influence climate change perception, according to Altea (2020). Access to information on meteorological conditions may be associated with farmers' location; and hence their climate change perceptions (Roco *et al.*, 2015). For example, farmers located near the regional capital city are reported to be more knowledgeable about the actual changes in weather compared to those located farther away.

2.5 Impacts of Climate Change on Crop Production and Food Security

Global food security in the current century faces a myriad of threats including climate change making it a dilemma to sustain the burgeoning global population sustainably (Thompson *et al.,* 2010). The change of the global climatic conditions presents a significant risk to agricultural production (Vermeulen *et al.,* 2012). In 2007, the Food and Agriculture Organization (FAO) projected a drop in the grains and livestock yields in SSA which would impact food availability where most of the population was resource-constrained and had limited coping mechanisms to ecological stress. Additionally, alteration of the distribution of agro-climatical zones could lead to changes in crop production (Hulme *et al.,* 2001). In particular, weather variations may cause a shift of land suitable for crop cultivation; resulting in improved productivity in highlands zones and decreased lowlands (Ludi, 2009; IPCC, 2014).

The World Bank (2007) has identified rainfall variations, temperature changes, and overland flow as the main climatic factors impacting crop production. The consequences of changing climate on crop produce will fluctuate from area to area, either after a rise or a decline in production, as noted by Alexandratos & Bruinsma (2012). Moreover, changes in precipitation and temperature trends may alter the current agroecologies, affecting soil moisture dynamics and growing period lengths (Kurukulasuriya & Rosenthal, 2013). Crops require sufficient soil moisture for growth, and precipitation plays a significant part in providing it (Kogo *et al.,* 2021). The IPCC (2014) has predicted that the anticipated temperature increase will lead to low crop yields, leading to a significant reduction in crop harvests.

In Ghana, Derbile *et al.* (2022) revealed that annual climatic events, such as water scarcity, flooding, sunshine, and bushfires, have serious consequences on food crop farming and agricultural systems. Similarly, Agesa *et al.* (2019) observed that erratic rainfall, droughts, deficient fertility of the soil, and deficient soil moisture were the main features attributable to the decreased crop yields. Along the same lines, Thornton *et al.* (2009) report crop production decline in East Africa was attributed to the change in climate, whereby temperatures have increased, rains are erratic, and land degradation is being experienced in agriculturally viable land. Other threats to food security by other authors include increased incidences of floods, crop losses, poor crop yields, livestock deaths, declining fish catches, and strange pests and diseases (Idoma & Mamman, 2016; Popoola *et al.*, 2019).

2.6 Access to Climate Change Information and Sources

Climate change information is essential for agricultural decision-making and adaptation (Muema *et al.,* 2018). It can also improve knowledge, resource consumption, and productivity among farmers (Kahimba *et al.,* 2015). This information is fundamental to agricultural sustainability since it assists farmers in tackling climate change-related hazards while also contributing to the achievements of SDGs 1, 2, and 13 (Ambani & Percy, 2012). On the other hand, information sources are also critical for alerting farmers to utilize new information in preventing climate change in the most effective way possible (Evaristo & Emmanuel, 2020).

According to Chukwuji *et al.* (2019), farmers in Nigeria's Zamfara State had accessibility to climate change information, including predicting animal diseases, mitigation, fish farming, enhanced crop varieties, irregular precipitation, flooding, and rainfall forecasts, and the farming of short- and long-term crop varieties. Muema *et al.* (2018) found that while more than 50% of the families accessed seasonal climate information services (CIS), fewer than 50% of those who obtained CIS used it to adapt their farms to climate change consequences. Popoola *et al.* (2020) emphasize the criticality of smallholder farmers accessing climate information, such as improved breeding practices, better use of cultivars, appropriate livestock pest and disease management, and the adoption of modern farming systems, to efficiently cope with the changing climatic conditions.

Iwuchukwu & Udoye (2014) found that farmers in Nigeria get their information about climate change through newspapers (95%), radio (64%), neighbors (68%), and friends (56%). A lower percentage obtained climate change information via television, an extension agent, and their spouse. This indicates that these farmers obtained climate change information from both institutional and informal sources. Cucumber farmers in Enugu, Nigeria rely on a variety of sources for climate information, including other farmers, neighbors, and friends, as well as their own experiences, according to Asadu *et al.* (2018). Additionally, Popoola *et al.* (2020) demonstrated that out of 16 identified sources of information in the Amathole District of South Africa, TV, radio, informal gatherings, print media, and government extension services were listed as the highest in terms of significance. The inference is that public extension services are less effective than mainstream media—in this example, newspapers, radio, and television—at disseminating information about climate change. Evaristo & Emmanuel (2020) also noticed that the majority of farmers in Tanzania's Mvomero District receive climate change information via radio.

Older household members have limited access to climate information, whereas farming, family income, television ownership, belonging to groups, farm size, and family size promote climate information access (Muema *et al.,* 2018). Additionally, social and economic status, group memberships, culture, and communication resources access are all aspects that would influence climate change information access (Adger *et al.,* 2003; Elia, 2013). Accessing climate information is also directed by socioeconomic characteristics, including occupation, education, and income (Mtega, 2012; Dang *et al.*, 2019). According to Evaristo & Emmanuel (2020), farmers' ability to obtain climate information is determined by their degree of education. Income (Evaristo & Emmanuel, 2020) and education level (Cheriotic *et al.,* 2012) enable farmers to gain greater accessibility to climate information, allowing them to prepare ahead of time for adaptation plans targeted at curtailing the detrimental outcomes of the climate crisis (Muema *et al.,*2018).

2.7 Challenges Farmers Encounter in Accessing Climate Change Information

Climate information is essential for farmers, but several challenges hinder its accessibility and effective utilization. These challenges include the use of media that is inaccessible to rural communities, cultural barriers, limited access to educational materials, illiteracy, inadequate knowledge of climate conditions, sex roles, and disparities, poor translations of climate change terminologies, delayed information delivery, the technical complexity of the message, geographic isolation, inadequate access to radio, television, and poor internet connectivity and mistrust in information sources (Idoma & Mamman, 2016). Other authors, for instance, Ifejika *et al.* (2010) and Kristjanson *et al.* (2014), reinforce the proposition climate change communication is hampered by social, cultural, technology, and context-related challenges.

2.8 Research Gaps

Existing literature has analyzed the consequences of climate emergencies on agriculture and indicated that farmers can substantially moderate the damaging outcomes of climate change by using adaptation techniques. Even when such studies have focused on adapting agricultural techniques to changing climate, these studies rarely specify farm-level adaptation approaches targeted at specific locations and production systems. A variety of factors affecting adoption among small-scale households have been emphasized in the reviewed literature. Family and farm characteristics, along with institutional characteristics, are the major factors influencing adoption. However, there is no empirical data that supports factors influencing farmers' adaptation strategies in the research area. Other literature provides insufficient and general information, and yet adaptation techniques differ contextually and geographically (across communities and perhaps among individuals). Additionally, these studies overlook important climate information such as the seasonal forecast, which provides estimates of rainfall and temperature in the upcoming two or three months. In particular, this parameter is significant for farmers in Somalia, particularly in the Hiran region of Somalia. Therefore, the study's purpose is to contribute to closing this gap.

CHAPTER THREE: METHODOLOGY

3.1 Study Area

3.1.1 Geographical Location of the Study

Hiran is a central Somali administrative region and part of the Hirshabelle State, with a population of 520,685 people (UNPF, 2014). As indicated in Figure 3.1, Hiran is bordered to the northwest by Ethiopia, to the northeast by the Somalia regions of Galgaduud, to the south by the middle Shabelle, to the southwest by the lower Shabelle, and the west by Bay and Bakool.

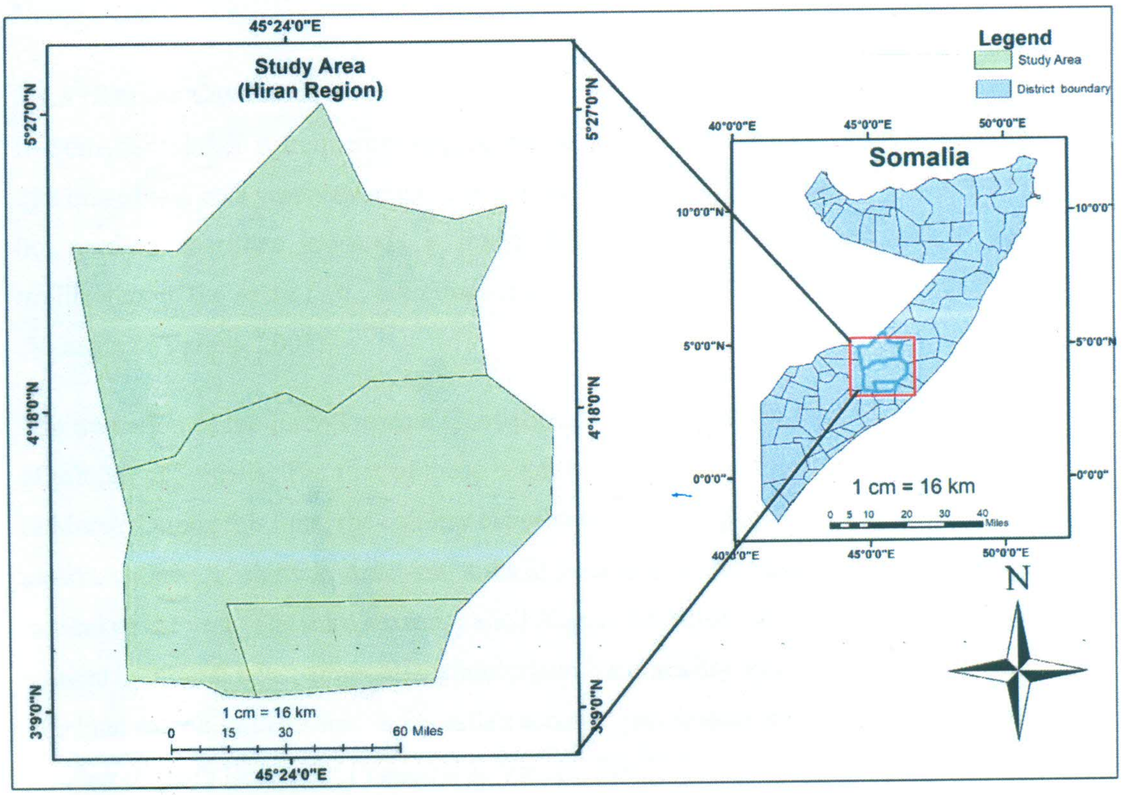

Figure 3. 1: The Map of Hiran Region. Source; Odawa (2022).

3.1.2 Economic Activities

Irrigated agriculture is performed in the area on the alluvial plains in a short band near the Shabelle River. Controlled irrigation and flood irrigation are the two main methods of irrigation used, and water is discharged from the river in both cases and moves by gravitation or is pumped by diesel engines. Water is channeled by canals and furrows to the plants in controlled irrigation. Under flood irrigation, natural downturns or flat areas contained by constructed river banks are flooded for a length of time, saturating the soil. Maize, sesame, fruits, and vegetables are the principal crops on small, irrigated plots, while bananas, guavas, lemons, mangoes, and papaya trees are the main crops in the few large-scale plantations (Venema & Vargas, 2007).

Sheep, goats, cattle, camels, and donkeys are some of the animals raised in the study area; they produce milk, beef, and skins, as well as butter, for primarily business and household purposes. Sedentary farmers in the study area combine agricultural production with animal farming. They normally maintain a small number of cattle, sheep, and goats close to houses when herding nomadic stock, whereas non-lactating animals are herded further away. Rain-fed and irrigation farmers, on the other hand, keep a modest quantity of livestock, primarily cattle and small ruminants (Venema, & Vargas, 2007).

3.1.3 Climatic Conditions

In Somalia, rainfall is frequently unpredictable and low. The nation receives roughly 250 mm of rain on a yearly average. The average annual rainfall in the severely dry and hot northern maritime lowlands is fewer than 250 millimeters, compared to 400 millimeters in the south (e.g., the Hiran region) and 700 millimeters in the southwest (Venema & Vargas, 2007).

The migration of the Inter-Tropical Convergence Zone results in four distinct seasons of rainfall in Somalia. The first of these is known as *Jilaal,* and it occurs from January to March. During this time, the country experiences a prolonged dry season. The second season, called *Gu,* starts in April and ends in June and is characterized by the heaviest rainfall of the year. The third season, called *Xagaa,* lasts from July to September and is marked by littoral rains, although the hinterland becomes dry and cool during this time. The final season, called *Deyr,* is Somalia's second rainy season and is experienced from October through December (Venema & Vargas, 2007).

3.1.4 Land Cover

The categories of vegetation in the study area, according to Pichi-Sermolli (1957), include scrub in the desert, arid zone xerophyllous open woods, and semi-arid zone xerophyllous open woodland. Others include savanna, coastal morphologies, palustrine forms, grass, perennials, sub-shrubs, steppe, and riparian formations.

3.1.5 Land Use

Most of the land is utilized for grazing, construction, and wood gathering. Livestock such as goats, sheep, cattle, and camels graze on rangeland surrounding the river basin. Although livestock is individually owned, grazing areas are communal, making range management a challenge. Rangelands are used by herders as part of their transhumance efforts (Venema & Vargas, 2007).

3.2 Research Design

The study design was a survey. Quantitative research frameworks were used using both descriptive statistics and econometric techniques. A survey was adopted during this investigation to thoroughly and accurately depict the subject at hand. This approach involved the collection and analysis of information to gain a comprehensive comprehension of the situation being examined.

3.3 Target Population

The study's target population was the smallholder farming community in the Hiran region. The districts of *Beledwein* and *Buloburte* in the Hiran Region were purposefully chosen because they are home to smallholder farmers who cultivate cash and subsistence crops, such as maize.

3.4 Sample Size and Sampling Procedure

The sample size (n) was determined according to Yamane (1967) formula:

$$= \frac{N}{[1 + N(e)^2]} \qquad \text{Equation (1)}$$

Where; N = the target population, and e = alpha.

i.e., n = 1200/(1 + 1200 x 0.0025) = 222. The n = 222.

This study used random and purposive sampling procedures. Initially, the *Beledwein* and *Buloburte* Districts of the Hiran Region were purposefully selected Because these districts are primarily agricultural producers, with a few families raising domestic livestock for sustenance purposes. Then, six (6) villages (three from each district) with a population of 1200 households were also purposefully chosen again, due to their location at the riverbank and exposure to climatic extremes in recent years, such as floods and droughts (Table 3.1). The households were then chosen at random from each of the purposefully chosen villages to form the 222-person target sample. The sample size in each target village was established proportionally to the population size (Table 3.1).

Table 3. 1: distribution of the respondents by the sampled villages

Districts	Villages	No. of the farmers	Sample Size (n)
Beledwein	Baareey	200	50
	Camalow	155	35
	Bulo-xaabley	150	30
Buloburte	Caag-bashiir	200	50
	Jameeco-shiin	155	35
	Galmadoobe	140	22
Total			**222**

3.5 Data Collection Instruments

A structured questionnaire was established, with both open and closed-ended questions included. Questionnaires were distributed to the respondents in the selected villages. Survey research allows the investigator to meet with respondents in person to communicate the research objective and help them fill out the questionnaires.

3.6 Validity and Reliability Test

To safeguard validity, survey tools were revised by supervisors and colleagues to see if they contained items that could be used to measure study objectives. Corrections and re-checking were made before the final draft was made. Following the evaluation of the questionnaire, the necessary changes were made while keeping the study's objectives in mind. A test-retest procedure was made to determine the instrument's reliability. The questionnaire was piloted on 35 respondents (15% of n), who were excluded from the final survey. Each set of questions in all three objectives was exposed to a reliability test by Cronbach's alpha. Test question sets were considered reliable for the accuracy of the model of research when all of the sets had coefficients of determination greater than 0.7.

3.7 Data Analysis

Data were coded into SPSS version 26 and further exported to STATA version 14.1 for statistical analyses. To support the conclusions of econometric approaches, descriptive statistical tools including frequency, percentages, means, tables, and figures were used.

A probit regression model was used to analyze how the socio-economic characteristics of the farmers influence their perception of climate change. Because the dependent variable in the study was binary, the probit model was implemented. In this case, the perception of the farmers was coded 0 if a farmer had perceived it and 1 if not perceived (Table 3.2). The probit model has been commonly employed in previous research, such as in the study by Fahad *et al.* (2020) which examined farmers' level of awareness and perceptions of climate change in Pakistan.

Table 3. 2: Definition of (Socioeconomic and institutional characteristics) influence the perception, adaptation measures, access to climate information, and the sources of the farmers

Variables	1. Farmer's perception 0=Perceived: 1= Not Perceived 2. Different Adaptation measures 0= Yes: 1= No 3. Climate information access 0= Accessed:1= Not accessed 4. Difference information sources 0= Yes: 1= No	
Variables	**Category**	**Unit of measurement**
Socioeconomic Factors		
Gender	Dummy	0= Male 1= Female
Age	Continuous	Number of years
Marital status	Dummy	0=Married 1= Unmarried
Family size	Continuous	Number of family members
Education level	Dummy	0= Formal 1= non-formal
Farm income	Continuous	Monthly farm income (USD)
Farming experience	Continuous	Number of years in farming
Farm size	Continuous	Number of Hectors
Land acquisition	Dummy	1. Inherit 2. Purchase 3. Rent
Non-farm income	Dummy	0= Yes 1= No
Farming system	Dummy	1. Crop production only 2. Livestock rearing 3. Mixed
Communication devices	Dummy	0= Yes 1= No
Types of communication devices	Dummy	1. Mobile and Radio 2. Radio and Tv 3. Mobile 4. Mobile, Radio, and TV
Institutional Factors		
Access to credits	Dummy	0= Yes 1= No
Access to extension services	Dummy	0= Yes 1= No
Support for extension services	Dummy	0= Yes 1= No
Distance to the market	Continuous	number of the nearest market (KM)

The binary logistic regression method was utilized to identify the factors that affect the farmers' adaptation strategies in response to the consequences of climate hazards, as well as their access to climate information and sources in the Hiiran region of Somalia (Table 3.2). The beneficial characteristics of this maximum likelihood estimation-based model are its consistency and asymptotically efficient parameter estimation (Naanwaab *et al.*, 2014). Due to the binary structure of the dependent variable, it can also contain a lot of explanatory variables (Achieng, 2017).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Demographic Features of Respondents in Hiran Region, Somalia

These results indicate that 83% of the farmers were male compared to 17% of female. Furthermore, the majority (80%) of the farmers were married, while 20% were unmarried. The result also revealed that 29% of the farmers have formal education while 71% have non-formal education. The average number of family members found in this study was 6, with the smallest family having 2 members and the largest having 12. The average age of the participants was 39 years, with the age ranging from 20–65 years. The mean farming experience of a farmer was 20 years, with the least experienced having 2 years and the most experienced having 30 years. The average monthly household income for the participants in the Hiran region of Somalia was 180 USD, with the least being 100 USD and the most being 250 USD. Also, 77% of the farmers had a source of non-farm income, while the other 23% solely relied on crop cultivation as the major form of livelihood (Table 4.1).

Sixty-seven percent (67%) of the farmers inherited their land, 19% purchased it, and 14% rented it. Furthermore, 52% of the farmers practice crop production only, 2% rear livestock only, and 46% practice mixed farming. Additionally, the average farm size among the respondents was 3 ha (ranging from 1–8 ha). Farmers in possession of their own communication devices were 85%, while 15% did not. Of those who own communication devices, 67% have a mobile and radio, 4% have a radio and TV, 10% have only a mobile, and 19% have a mobile, radio, and TV. Furthermore, access to credit/loans and agricultural advisory services is 77% and 73%, respectively. Of those who have access to extension services, 54% reported receiving support from extension agencies. The average distance to the nearest market among the respondents was 6.5 kilometers, with the closest market being 2 kilometers away and the farthest being 20 kilometers away (Table 4.1).

Table 4. 1: Socio-economic and Institutional Characteristics of the Farmers in Hiran Region, Somalia

Variables	Descriptions	Frequency	Percentage (%)
Gender			
	Male	184	83
	Female	38	17
Marital status of the farmer			
	Married	178	80
	Unmarried	44	20
Educational Level of the Farmer			
	Formal Education	65	29
	Non-Formal Education	157	71
Land acquisition of the farmer			
	Inherited	149	67
	Purchased	41	19
	Rented	32	14
Non-farm income of the farmer			
	Yes	170	77
	No	52	23
Farming system of the farmer			
	Crop cultivation only	116	52
	Livestock keeping only	4	2
	Mixed farming system	102	46
Communication devices			
	Yes	188	85
	No	34	15
Types of communication devices			
	Mobile and Radio	129	67
	Radio and TV	8	4
	Mobile	19	10
Access to any credits/loan			
	Yes	171	77
	No	51	23
Access to agricultural advisory services			
	Yes	161	73
	No	61	27
Support from the agricultural extension agencies			
	Yes	121	54
	No	101	46
	Mean	**Minimum**	**Maximum**
Age of the respondent (in years)	39	20	65
Number of total family members	6	2	12
Farming experience	20	2	30
Farm size in Hector	3	1	8
Mean monthly household income (In USD)	180	100	250
Distance from the market in Km	6.5	2	20

Farming activities were mostly carried out by males in the Hiran region of Somalia probably because men are more capable of heavy farm operations compared to women

(Adesiji *et al.*, 2012). This may also be related to the adverse influence of traditional norms and customs on women (Aravindakshan *et al.,* 2020). Additionally, the majority of the farmers in the Hiran region of Somalia were married (Table 4.1), thus adding responsibility to provide for the family, necessitating seeking information on climate and technology to improve families' well-being. Marital status therefore led to proper utilization of agricultural, and climate information and technologies according to Idrisa (2009).

Most of the farmers in the Hiran region had non-formal education (Table 4.1). Education contributes to the uptake of innovations and technologies, as it boosts the farmers' skills to gather, analyze, and apply information. According to Ayal *et al.* (2021), educated farmers utilize their farm capital wisely, and demonstrate the capacity to analyze and interpret information. Moreover, Kifle *et al.* (2022) reported that farmers with advanced levels of education are naturally more risk-takers and more eager to adopt climate-smart agriculture (CSA) practices than those with lower levels of education. Idoma & Mamman (2016) also argued that advanced education enhances the likelihood of farmers' exposure to information on climate variability.

The household size was 6.5, which corresponds to Somalia's national statistics (United Nations Population Fund, 2014). These findings suggest that the majority of households had a substantial number of individuals for domestic labor resources, promoted networking and facilitated access to information for farmers, and also access to non-farm labor opportunities diversifying household income, which is critical for adapting to the consequences of climate conditions. For instance, large family sizes with several labor-productive individuals boost farm output since they are related to labor-intensive farming techniques (Kurukulasuriya & Mendelsohn, 2008; Gbetibouo, 2009). As a result, household size could be significantly correlated with some of the adaptation categories. Larger family sizes often engage in CSA activities than their counterparts, thereby increasing their chances of adopting new technologies (Kifle *et al.*, 2022), hence improving their resilience to the hazardous consequences of climate crises.

Respondents' age data demonstrated that the majority fell in the active age bracket and were old enough to have observed the variations in the climate variables (Table 4.1). Consequently, they can significantly improve the region's food security through various means such as expanding farmlands and providing farm labor. On average, the farmers had 20 years of experience in farming, which is critical in recognizing and engaging in locally smart practices. Experienced farmers diversity and transfer risks associated with climate shocks in crops, rearing animals, and engaging in non-farm-related activities than their counterparts since they possess high capabilities in agricultural practices and management (Ndambiri *et al.*, 2014).

The average farm income of the respondents was 180 USD, which indicates that their capability to prepare for the weakening consequences of the changing climate can be hindered by low household income. Poverty is a significant constraint to accessing and utilizing climate change information (Arokoyo, 2005). Elsewhere, cognizance of and the response to the worsening condition of the changing climate are extremely related to income levels among smallholder farmers (Tesso *et al.,* 2012). However, most farmers in the Hiran region of Somalia had other sources of income rather than just farm income. Ojo & Baiyegunhi (2020) argue that smallholder farmers who have diversified income sources can overcome their financial limitations.

The farmers in the Hiran region of Somalia had the availability of farming assistance services (Table 4.1). Farmers' access to agricultural advisory boosts their access to information and provides them with specialized and localized information, which may include facts about the changing climate and its possible consequences on their specific location. They can also learn about innovative technologies and acquire the necessary inputs and services, which serve as a determinant factor in the capability to acclimatize to climate hazards. Extension services promote adaptation by improving farmers' perceptions of climate hazards and understanding of adaptation techniques (Nhemachena & Hassan, 2007; Falco *et al.*, 2011). Conversely, although significant numbers of farmers in the Hiran region had access to advisory services, only half of them reported receiving support from these agencies. This may indicate that there are issues with the quality or reliability of extension services in the region, which need to be addressed. According to Kimaru-Muchai *et al.* (2020) providing support through training and assistance from extension services, NGOs, and international agencies is essential in promoting farmers' access to information and increasing their likelihood of adopting innovations to improve agriculture.

Most farmers in the Hiran region of Somalia had access to credit/loans. According to Fosu-Mensah *et al.* (2012), higher credit availability allows agriculturalists to acquire enhanced hybrid seeds, fertilizer, certified crop varieties, and soil moisture management systems to promote agricultural productivity. Additionally, Kifle *et al.* (2022) argued that accessibility to inexpensive loans rises the chances of smallholder farmers adopting CSA practices, which subsequently helps ensure food security and improves income. Likewise, Tesso *et al.* (2012) emphasized how credit service is a critical element affecting farmers' perceived climate change effects.

In regards to communication devices, most farmers in the Hiran region own communication devices such as mobile, radio, and TV. This can have important implications for climate adaptation and access to climate information. Communication devices provide an avenue for disseminating climate information to vulnerable communities that may be affected by climate hazards. By using these devices, weather forecasts, early warning systems, and other relevant climate information can be broadcast to the farming community enabling them to make knowledgeable decisions regarding planting, harvesting, and pesticide application, which can help reduce the risks associated with extreme weather events. According to Hampson *et al.* (2014) and Oyekale (2012), owning a communication device such as a television or a radio boosted exposure to weather event predictions in South Africa and sub-Saharan Africa, respectively.

The study further discovered that the farm size among respondents was 3 ha, with most farmers inheriting their land and solely engaging in crop production (Table 4.1). This means farmers operate on a small scale and could limit their potential to adopt modern farming practices that require economies of scale, such as mechanization and irrigation systems, which can affect their productivity and competitiveness. Moreover, there may be limited access to land for new entrants into farming, which can be a barrier to entry for young and aspiring farmers. Additionally, there is also a need to diversify farming activities to enhance the profitability of farming. Diversification into livestock or fisheries, for example, can provide opportunities for farmers to tap into new markets and increase their income streams. Moreover, the majority of farmers in the region live about 6.5 km away from the nearest market. As reported by Vorley *et al.* (2009), closeness to the market facilitates sharing and information exchange among different stakeholders; thus, communities closer to markets are more likely to adopt innovations brought on board than their counterparts. Moreover, the market is a critical element of the coping mechanisms as it acts as a way of sharing information with other stakeholders (Maddison, 2006).

4.2 Socio-economic Factors Influencing Farmers' Perception of Climate Change

4.2.1 Farmers' Perception of the Long-Term Change of Climate Variables

Seventy-eight percent (78%) of the respondents observed changes in temperature and rainfall in the past 20 years, unlike their counterparts (22%) (Figure 4.1).

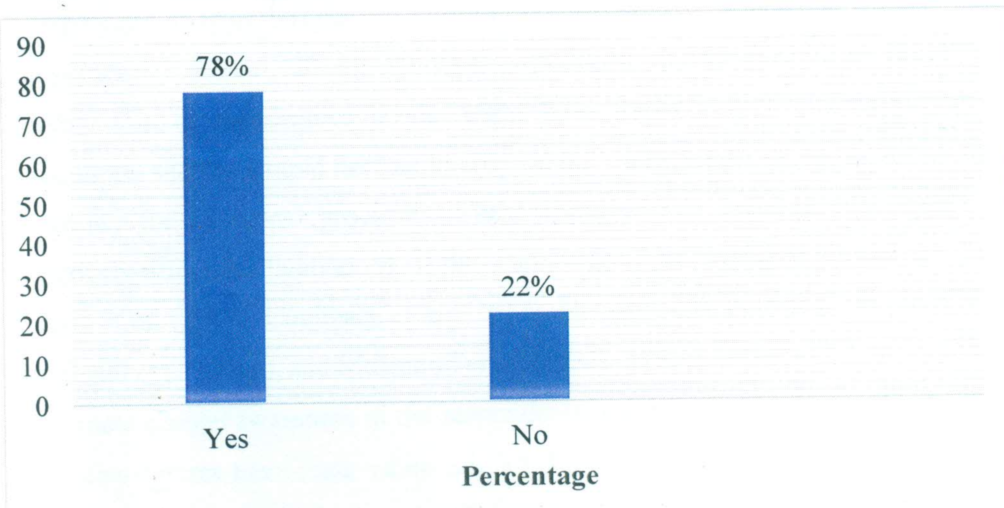

Figure 4. 1: Farmers' Perception of Climate Change in Hiran Region, Somalia

These findings suggest that there is a widespread perception among the respondents that the climate has been changing over the last two decades. Since rain-fed agriculture is the main source of income for the majority of farmers, therefore, any changes in the climate would be quickly recognized by local farmers. According to Maddison (2006), awareness of climate change is a necessity for communities to take up coping strategies. Therefore, the perceptions of the community on climate change could increase their probability of taking adaptive actions to respond to observed changes.

The temperatures in the region have been increasing according to 86% of the respondents while 14% of the respondents stated that the temperature in the region has been decreasing. Rainfall data showed a similar consistency of opinion. In the past 20 years, rainfall duration and intensity have decreased according to 84% and 87% of the farmers, respectively (Table 4.2).

Table 4. 2: Percentage of Farmers Who Have Experienced Changes in Temperature and Rainfall Events of Farmers in the Hiran Region, Somalia

Climatic parameters	**% of Respondents**	
	Increased	**Decreased**
Increased Temperature/Decreased Temperature	86	14
Increased rainfall duration/Decreased rainfall duration	16	84
Increased in rainfall intensity/Decreased in rainfall intensity	13	87

Temperature increase inflicts harm not only on agricultural production but also to the ecosystems (Adebayo, 2012). Moreover, according to Bhatti & Khan (2012), the gradual rise in temperature levels might have major negative consequences on agriculture, such as a rapid decline in crop output when temperatures rise above those necessary for biological processes. These changes may decrease crop yields and negatively affect the livelihoods of the community if no coping strategies are taken. Kassie *et al.* (2013), Coulibaly *et al.* (2017), Nanjappan & Parameswaranaik (2019), Fourment *et al.* (2020), and Mehmood *et al.* (2022) correspondingly reported high level of climate change awareness in the respondents under their studies and demonstrated that temperatures have risen while rainfall duration and intensity have decreased in Ethiopia, Rwanda, India, Uruguay, & Pakistan, respectively.

4.2.2 Determinant of the Farmers' Perception of Climate Change in the Hiran Region, Somalia

The probit regression model showed that gender, total family, farm size, and communications devices significantly influenced the farmers' climate change perception (Table 4.3). In contrast, the education level, marital status, non-farm income, and farming system of the farmers showed no statistical significance in influencing the farmers' perception of the impacts of climate change in the Hiran region of Somalia.

Table 4. 3: Socio-economic Factors Influencing the Perception of Farmers on Climate Change in Hiran Region, Somalia

Explanatory Variables	**Perception**		
	Coeff. (SE)	**Marginal effects (SE)**	**p-value**
Gender	.9077 (0.383)	.0972(.0389)	**0.013****
Total family	.1642 (0.075)	.01760(.0077)	**0.023****
Marital status	.7566 (0.372)	.0810(.0387)	0.069
Education level	.1757 (0.406)	.0188(.0432)	0.663
Farm size	-.7316 (0.133)	-.0783(.0119)	**0.000*****
Non-farm income	.2122 (0.352)	.0227(.0376)	0.546
Farming system			
Livestock rearing only	.1843(1.4061)	.02373(.1872)	0.896
Mixed farming	-5226 (0.4190)	.0590 (.04839)	0.222
Communication devices	1.1379 (0.382)	.1595(.0664)	**0.001*****
Prob > chi2 =	0.0000		
Pseudo R2 =	0.6571		
Number of obs =	222		

*Coeff: Coefficient SE: Standard Error in parentheses: ***, **, = significant at 1%, and 5%, probability level, respectively*

Gender had a significant positive association with farmers' climate change perception (Marginal effects = .0907, p-value = 0.013), which may suggest that male farmers were more likely to recognize the effects associated with the change of climate relative to female farmers. This difference in perception may be because men typically have more opportunities to obtain information about climate change and its implications, whether through formal education, access to communication devices, or participation in community meetings and activities. These findings are similar to Asfaw & Admassie (2004) and Tenge & Hella (2004), where men were more likely to notice changes in their environment than women. In line with this, Suvedi (2017) noted that female farmers were more unlikely to achieve the investment demands and typically have constrained authority on productivity and finances compared to male respondents.

Smaller families had fewer chances of recognizing climate change than larger families (Marginal effects = .0176, p-value = 0.023), thus agreeing with Falaki *et al.* (2013), Ndambiri *et al.* (2014), and Oluwatusin (2014). This could imply that farmers with bigger families are more likely to recognize the changes in climate variables effects than small families. This could be because bigger families have more available labor resources that can be used for crop and livestock production, which may make them keener on the changes in climate-related factors that impact agriculture (Table 4.3).

Conversely, farm size presented a significant negative association with farmers' perception of climate change (Marginal effects = -.0783, p-value = 0.000), suggesting that respondents with large farms are more unlikely to notice the effects of climate change than the ones with small farms. The negative correlation between the perception of the farmers and farm size in the current study corroborates with the findings of Sanog *et al.* (2012) and Uddin *et al.* (2017) in Southern Mali and the Coastal Region of Bangladesh, respectively. This is because farmers with bigger farms may have more resources and better capacity to adapt to changing weather patterns and may not perceive the effects of climate change as acutely as those with smaller farms (Table 4.3). Furthermore, mobile phones, radio, TV, and internet access, significantly correlated positively with farmers' climate change perception (Marginal effects = .1595, p-value = 0.001), thus agreeing with Howlader & Akanda (2015). Therefore, farmers who have access to communication devices show increased chances of perceiving climate change unlike those who do not have, because of better exposure to climate hazards information and possible adaptation strategies (Table 4.3).

4.3 Factors Influencing Adaptation Measures of the Farmers in the Hiran Region

4.3.1 Adaptation Measures of Farmers to Climate Change

In the Hiran of Somalia, (78%) of those surveyed for this study had adjusted their farming practices to account for long-term climate change. (Figure 4. 2).

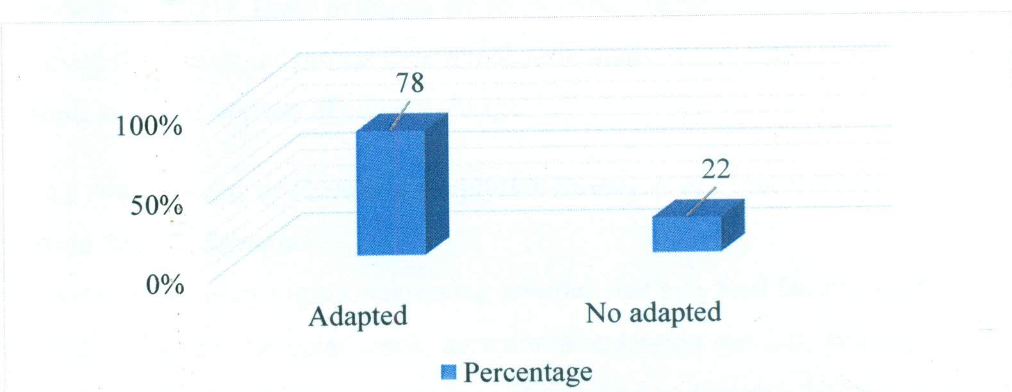

Figure 4. 2: Hiran Region Farmers' Adaptation to the Effects of Climate Change

Several adaptation mechanisms were employed by the farmers in the Hiran region of Somalia at their farmlands to cope with the unprecedented climatic catastrophe (Table 4.4). Soil and water management, minimum soil tillage, irrigation, and planting early maturing crops included the major adaptation strategies performed by the farmers in the Hiran region of Somalia. Greater use of soil and water management and minimum tillage could be due to affordability and readily accessible by farmers. The usage of irrigation might have been due to the farmer's proximity to the Shabelle River, which is the farmers' sole supply of water. Early crop planting can be connected to farmers' ability and willingness to harvest their crops and sell them quickly, thereby enhancing their adaptive capability.

Table 4. 4: Smallholder Farmer's Adaptation Mechanisms to Climate Change Effects in the Hiran Region, Somalia

Measures	Frequency	Percentages %
Crop diversification	104	60
Irrigation	106	61
Planting an early maturing crop	112	65
Use improved/resistant variety	101	58
Find off-farm employment	86	50
Input use such as seeds/fertilizers	88	51
Soil and water management	136	76
Minimum soil tillage	134	77

The farmers in the Hiran region have taken different adaptation mechanisms to address the challenges posed by changing climatic conditions like their counterparts in Kenya, Ethiopia, Nigeria, and Uganda (Ndambiri *et al.*, 2014; Melka *et al.*, 2015; Belay, 2017; Atube *et al.,* 2021). These strategies are likely to help farmers in the Hiran region better manage their farms and protect their livelihoods amidst the increasingly erratic weather trends and other impacts of climate change.

4.3.2 Determinants of Farmer's Adaptation Strategies of Climate Change Effects in Hiran Region, Somalia

The results in binary logistic regression revealed that age, total family, marital status, non-farm income, financial credit, agricultural extension services, and support from extension agencies, NGOs, and International agencies significantly influenced different adaptation measures toward climate change effects on the farmers (Table 4.5). Conversely, gender, education, proximity to the nearest market, and farm size of the farmers showed no statistical significance in influencing the adaptation strategies of the farmers.

Table 4. 5: Factors Influencing Farmer's Climate Change Adaptation Strategies in the Hiran Region, Somalia

		Factors and their model Marginal effects and p-value							
Variables		**Crop diver**	**Irrigation**	**Early maturing crop**	**Soil/water mgmt**	**Minimum tillage**	**improved variety**	**Off Farm jobs**	**Input use**
Gender	*M.E*	.1878	-.082	-.362	.054	-.029	.085	.261	-.208
	SE	.1313	.1072	.1973	.0636	.1355	.0928	.1378	.1250
Age	*M.E*	-.015*	-.005	-.004	.000	-.005	-.005**	.006	-.013*
	SE	.0034	.0030	.0038	.0034	.0035	.0027	.0034	.0035
Total family	*M.E*	-.073*	.007	-.007	-.041	-.024	-.010	-.013	.033
	SE	.0219	.0207	.0246	.0227	.0227	.0183	.0229	.0230
Marital status	*M.E*	-.088	.225**	-.176	.063	-.127	.161**	-.530*	.045
	SE	.1122	.0883	.1302	.1067	.1173	.0762	.1684	.1146
Education level	*M.E*	.047	.005	.080	.020	-.086	.077	-.021	.015
	SE	.0734	.0597	.0726	.0662	.0682	.0571	.0704	.0667
Farm size	*M.E*	-.000	-.016	.001	-.020	-.006	.000	.041	-.008
	SE	.0282	.0222	.0284	.0264	.0271	.0201	.0260	.0247
Non-farm income	*M.E*	-.043	.350*	-.526*	-.282	-.165	.447*	-.382*	.320*
	SE	.0901	.0674	.1809	.1562	.1111	.0834	.0953	.0912
Distance to the market	*M.E*	-.010	.007	-.015	-.039	-.028	-.005	.015	-.011
	SE	.0162	.0125	.0183	.0196	.0197	.0104	.0173	.0160
Access to credits	*M.E*	.100	.280*	-.327**	-.217	-.219**	.265*	-.257**	.397*
	SE	.0880	.0670	.1196	.1182	.1105	.0643	.0947	.1136
Access to extension	*M.E*	.157	.132	-.075	-.061	.149	.157**	-.077	.186
	SE	.0939	.0742	.1168	.1077	.0973	.0708	.0992	.1066
Support extension agencies	*M.E*	.096	.127**	.103	.052	-.019	.179*	-.171**	.176**
	SE	.0730	.0578	.0840	.0738	.0787	.0467	.0687	.0636
$P > \chi^2$		0.0000	0.0000	0.0000	0.0084	0.0863	0.0000	0.0000	0.0000
R^2		0.28	0.46	0.19	0.13	0.14	0.60	0.35	0.39
N of obs		173	173	173	173	173	173	173	173

*M.E= Marginal Effects, SE: Standard Error, *, **, = significant at 1%, and 5%, alpha, respectively.*

Farmer's age had a significantly negative effect on the practice of diversifying crops (*p = 0.000*), input use (*p = 0.000*), and improved/resistant varieties (*p = 0.046*), as adaptation strategies. This means that for each unit increase in the farmer's age, the probability of diversifying crop, input use, and using improved varieties decreases by -0.015, -0.013, and -0.005 respectively. This might be attributed that older farmers potentially have difficulties adapting to new agricultural practices or technologies and instead opt for alternative income sources. Older farmers tend to depend on traditional farming systems and are usually unwilling to take the risks of adopting new technologies (Mugi-Ngenga *et al.*, 2016). In contrast, youthful farmers are less risk-averse and tend to explore new technologies (Manda *et al.*, 2016; Denkyirah *et al.*, 2016; Ojo & Baiyegunhi, 2020).

The marital status determined the farmer's adoption of irrigation ($p = 0.011$), use of improved/resistant varieties ($p = 0.034$), and finding off-farm (alternative) employment ($p = 0.002$) as an adaptation strategy to the impacts of climate change. This means farmers in marriage were 0.225 times and 0.161 times more likely to adopt irrigation and improved/resistant varieties, respectively, than those not in marriage, and -0.530 times less likely to adapt to finding off-farm employment than their unmarried counterparts. This particular finding agrees with Gebre *et al.* (2019) that the likelihood that a farmer will adjust to the climate is increased when they are married. Other studies (Banful *et al.*, 2010, Kaliba *et al.*, 2018) also reported that married families have a higher propensity to employ hybrid seeds/cultivars. Besides, they had specified agricultural resource people, such as extension personnel and agricultural dealers relative to their unmarried counterparts who relied mostly on other farmers as their agricultural information source. In addition, Bawa *et al.* (2014) claimed that married individuals will be more receptive to learning about climate-smart technologies that could improve their families' well-being because they have more financial requirements.

In terms of family size affected the uptake of crop diversification ($p = 0.001$) as a coping strategy negatively. This entails that a unit rise in the size of the family reduced the likelihood of practicing crop diversification by -0.073. These results contradict with Ndambiri *et al.* (2014) where larger households adopt novel agricultural practices more readily than small households. This is because, with large family sizes, some family members divert the labor force to alternative income to meet the needs of the large family. Further, they may have more land and labor to manage, making it harder to implement practices such as crop diversifying crops and conserving soil and water on the farm (Table 4.5). The findings also differ from those of Ndamani & Watanabe (2016) and McCarthy *et al.* (2018) – where large families were associated with higher uptake of climate-resilient practices than small families.

Off-farm income showed a positive effect on the adoption of irrigation ($p = 0.000$), using improved/resistant varieties ($p = 0.000$), and input use ($p = 0.000$), but significant negative effects on planting early maturing crops ($p = 0.004$), and finding off-farm jobs ($p = 0.000$), as adaptation mechanisms to the consequences of the climate crisis. Suggesting that farmers with off-income were 0.350 times more likely to lead to the adoption of irrigation, 0.447 times more likely to use improved varieties, and 0.320 times more likely to input use, but -0.526 times less likely to the adaption planting an early maturing crop and -0.382 times less likely to adapt finding non-farm jobs to the consequences of the climate crisis compared to farmers without non-farm income. These findings corroborate with the assertion in Deressa (2009) that farmers with nonfarm incomes can pay for the cost of practicing agroforestry, and irrigating their crops as well as soil and water conservation and the use of different crop varieties. In the same way, according to Asayehegn *et al.* (2017), farmers with greater incomes who had developed the capability to overcome financial limitations to participate in new technologies were more likely to use more than one adaption technique. Adimassu and Kessler, (2016) also observed that wealthy families have more resources to respond instantly to reduce the consequences of the climate crisis than poorer households. Probably, smallholder farmers with off-farm income sources have the opportunity to access additional income, which they can use to purchase farm inputs and invest in climate-smart agriculture (Table 4.5).

Access to credits/loans by the farmers had a significant effect on the adopting of irrigation ($p = 0.000$), using improved/resistant varieties ($p = 0.000$), and input use ($p = 0.000$), finding off-farm employment ($p = 0.007$), planting early maturing crops ($p = 0.006$), and minimum soil tillage ($p = 0.047$). The findings suggest that access to credit is 0.280 times more likely to influence the uptake of irrigation, 0.265 times improved/resistant variety, 0.397 farm input, but -0.257 times less likely to influence the practice of looking for an alternative job, -0.327 times planting early maturing crops, and -0.219 times minimum soil tillage relative to lack of access to credit. This corroborates Tesso *et al.* (2012) findings that agricultural loans positively influence the use of climate-smart farming practices such as fast-maturing seeds and shifting to irrigated crop production. Access to credit and financial cash flows helps farmers invest in more expensive adaptation measures, such as irrigation and input use, which can lead to more profitable farming practices and reduce the negative impacts of climate change on food production. This result highlights the critical importance of greater institutional support in supporting the deployment of coping alternatives to lessen the detrimental climate change impacts.

Farmers' access to agricultural advisory services affected the adoption of improved or resistant varieties (*p = 0.026*). Farmers who obtained extension services were 0.157 times more likely to use improved varieties than their counterparts. According to Deressa *et al.* (2011) and Mudombi *et al.* (2014), access to extension services promotes households to embrace new technology on their farms, which can lead to increased agricultural output. These findings corroborate with Mabe *et al.* (2014) which reported that having accessibility to extension services for agriculture raises the probability that farmers will implement adaptation mechanisms for climate crises. In agreement with the current finding, Nhemachena & Hassan (2007), and Atube *et al.* (2021), also reported that extension services positively influenced the adaptation practices of the farmers.

The results also showed that support from agricultural extension, NGOs, and international agencies significantly affected the adoption of irrigation (*p=0.027*), using improved/resistant varieties (*p=0.000),* using inputs (*p=0.006*), and off-farm employment (*p=0.013*). Farmers that received support (e.g., training or improved seeds through workshops and seminars) from agricultural extension, NGOs, and international agencies were 0.127, 0.179, and 0.176 times more likely to practice irrigation, use improved varieties and use agricultural inputs, respectively, and -0.171 times less likely to find non-farm occupation as adaptation measures than those without support. Similar results have been reported in Okeyo *et al.* (2020), where farmer training had a favorable impact on smallholders' adoption of enhanced sorghum varieties. Additionally, they stated that trained farmers are more knowledgeable about various production patterns under shifting agroclimatic circumstances and frequently favor climate-smart agriculture. This is so because training farmers raises the farmer's capability to practice new agricultural technologies (Gebre *et al.*, 2019).

4.4 Factors Influencing Access to Climate Information and Information Sources by the Farmers in Hiran, Region, Somalia

4.4.1 Access to Climate Information by the Farmers in the Hiran Region

According to findings, 78% of the interviewed farmers had accessed some information on climate change, unlike only 22% (Figure 4.3).

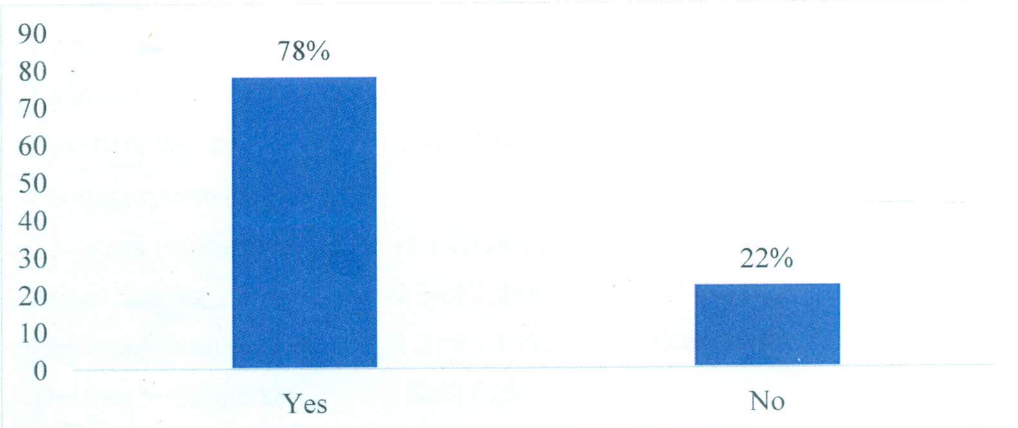

Figure 4. 3: The proportion of Farmers in the Hiran Region who had access or not accessed climate information

This suggests that a significant number of farmers in the Hiran Region are usually informed about local weather patterns and other environmental conditions that could affect their agricultural practices and livelihoods.

4.4.2 Determinants of Access to Climate Information by the Farmers

According to the binary regression model results, gender, marital status, education level, farm size, distance to the nearest market, and support extension agencies, NGOs, and international agencies significantly influenced climate information access (Table 4.6). Conversely, total family, farming experience, non-farm income, farming system, communication devices, extension services, and credits/loan facilities accessible to the farmers did not have a statistical association with how farmers got climate information in the Hiran Region.

Table 4. 6: Factors Determining How Farmers Get Information on Climate Change

Explanatory Variables	Climate information access		
	Coeff. (SE)	**Marginal effects (SE)**	**p-value**
Gender	2.444(1.119)	.0641(.0276)	**0.021****
Total family	.4071(.2405)	.01068 (.0060)	0.077
Marital status	2.659(1.330)	.0697(.0332)	**0.036****
Education level	3.275 (1.731)	.0859(.0431)	**0.046****
Farming experience	-.0258 (.1202)	-.0006(.0031)	0.829
Farm size	-1.654 (.5446)	-.0434(.0117)	**0.000*****
Non-farm income	1.013(1.076)	.0265(.0278)	0.340
Farming system (1)			
Livestock rearing only	-1.147(14.150)	-0259(.3165)	0.935
Mixed farming	2.349(1.894)	.0614(.0457)	0.179
Communication devices	1.255(1.1899)	.0329(.0303)	0.278
Distance to the market	.5292 (.1571)	.0138(.0032)	**0.000*****
Access to credits/loan	1.284 (1.159)	.0336(.0295)	0.255
Access to extension	1.655 (1.057)	.0434(.0261)	0.097
Support extension agencies	3.307 (1.426)	.0867(.0345)	**0.012****
Prob > chi^2	0.0000		
Pseudo R^2	0.8303		
Number of obs	222		

Coeff: *Coefficient: SE: Standard Error: ***, **, = 99%, and 95%, confidence intervals, respectively. Values in brackets are SE.*

Gender was positively and significantly associated with climate information access (marginal effects =*0.064, p= 0.021*) (Table 4.6). This suggests that male farmers in the Hiran Region were getting information related to climate change in a greater manner than female farmers. Possible arguments for this significance could include a lack of educational or economic opportunities for women in the agricultural sector or a lack of representation of women in extension services or other sources of climate information. Other possible arguments could be that men may be exposed to better opportunities to be in meetings and workshops where climate information is disseminated or that more men own radios, mobile phones and have internet connections than women. Socially, men are considered the primary landowners and decision-makers in agriculture

(Nwangi & Kariuki, 2015). As a result, they often have more control over the information that is accessed and utilized in farming. These results agree with Coulibaly *et al.* (2017) and McCarthy *et al.* (2018) proposition that more male farmers get climate information than female.

The results have shown a significant correlation between access to climatic information and the state of marriage (Marginal effects $=0.069$, $p= 0.036$). This suggests that it is more possible for the farmers who are married to get climate information compared to the unmarried ones. Farmers in low-income countries practice communal farming and traditional farming and farm productivity is gender-diverse and family size dependent (Mwalukasa, 2013). Married people have wide social networks which increase their chances of getting more information including those related to climate than unmarried people (Evaristo & Emmanuel, 2020). Additionally, Deressa *et al.* (2008) argued that since extended families are common among married farmers in developing nations, each one might be a source of information. Therefore, married farmers could be more knowledgeable about climate change than unmarried farmers (Evaristo & Emmanuel, 2020). Possible arguments for this significance could include the support and resources provided by a partner or the shared decision-making and communication among married farmers.

Level of education also had a positive association with whether or not a farmer was getting climate information (marginal effects $=0.085$, $p=0.046$) (Table 4.6). This suggests that respondents who reported having greater education were receiving more knowledge on climate change than respondents who had less education. Probably educated farmers have more access to assets, knowledge, and info through education, or they are conscious of the importance of climate information in their farming activities. Education improves comprehension of the best agricultural practices for adjusting to the negative effects of climate crises by enhancing effective climate monitoring (Evaristo & Emmanuel, 2020). This supports the observation of Adolwa *et al.* (2012) that to access information and engage in the information-seeking process, a certain amount of literacy and knowledge is often required.

Regarding farm size, a negative association was established between whether or not farmers were getting climate information and farm size (marginal effects = -0.043, $p= 0.000$) (Table 4.6). This suggests that as the farm size increases, farmers' access to climate information decreases. These findings do not agree with Rehman *et al.* (2013) study proposition that an increasing farm size results in a high probability of getting good agricultural information including on climate. Elsewhere, Muema *et al.* (2018) reported that households with big farms can diversify crop alternatives and disperse risks associated with the unpredictability of climate, leading to increased demand for climate information. Similarly, farmers who own big farms have a stronger need for climate knowledge due to the size of the anticipated losses linked to climate change (Oyekale, 2015). The negative association noted in this study could, however, be attributable to the tendency that larger farms may have greater resources and information access through their networks, lowering their need to seek out other sources of climatic information.

Distance to the nearest market was positively correlated to farmers' access to climate information (marginal effects = *0.013, p = 0.000*) (Table 4.6). This suggests that farmers who live closer to the market have higher contact with climate information compared to their counterparts. This could be so since farmers who live closer to the market may have more opportunities to interact with extension agents and other farmers, which can increase access to information and resources. Accessibility to markets, according to Hassan & Nhemachena (2008), encourages farmers to generate surplus crop yields and other farm produce that may be readily taken to markets, increasing their revenue and enhancing their capacity to deal with the impacts of the changing climate. In this study, support for extension services, NGOs, and international agencies has a significant positive relationship with climate information access (marginal effects = *0.086, p=0.012*) (Table 4.6). Indicating that farmers who get support from agricultural extension services, NGOs, and international agencies get more climate information than their counterparts. Supporting farmers by the provision of resources for example information and training may assist farmers in improving and sustaining high productivity amid climatic change (Nhemachena & Hassan, 2007).

4.4.3 Sources of Climate Information by the Farmers in Hiran Region, Somalia

In the study area, farmers access climate information through different channels as shown in Figure 4.5. Radio (95%), agricultural extension officers (80%), and personal observation (75%) were the most climate information sources by the farmers in the Hiran region of Somalia.

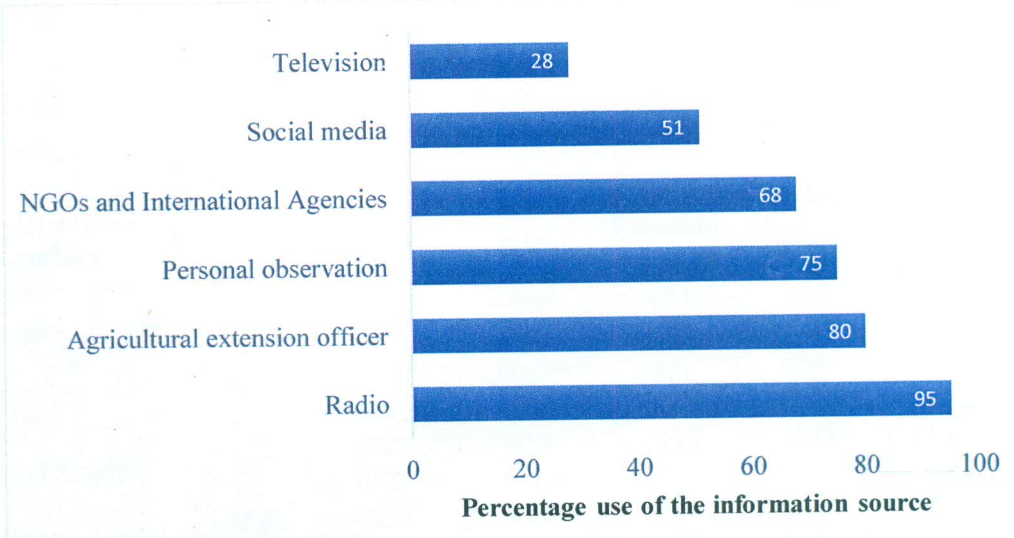

Figure 4. 4: The Farmers' Sources of Climate Information on Climate Change

These results show that radio, agricultural extension officers, and personal observation were the most prominent climate change information sources among farmers in the Hiran region of Somalia, while NGOs international agencies, social media, and TV were the least preferred (Figure 4.5). In agreement with the current results, Csoto (2010), Okoro (2016), and Limantol *et al.* (2016) observed that radio, agricultural advisory services, personal observation, and TVs were the major means of accessing climate forecasts in the countryside. Accessibility, affordability, and availability of radio make it preferred by farmers over other sources for information on climate change (Singh *et al.,* 2016; Muema *et al.,* 2018). Radio has also been associated with cheap costs, low maintenance costs, and broad coverage of information on climate change (Oyekale, 2015). Furthermore, Ojo & Baiyegunhi's (2020) interactions with extension agents provide access to the information that is needed by the farmers to make informed judgments about which climate change adaptation techniques to employ.

4.4.4 Determinants of Climate Information Sources by the Farmers

According to the binary logistic model results, the climate information sources available to the farmers were significantly dependent on age, ownership of communication devices, access to credits, and support extension agencies, NGOs, and International agencies (Table 4.7). On the other hand, gender, total family, education level, alternative income, size of the farm, and nearest market distance showed no statistical significance in influencing climate information sources of the farmers in the Hiran region of Somalia.

Table 4. 7: Factors Influencing Sources of Information Relating to Climate by the Farmers in Hiran Region, Somalia

Independent Variables		Information sources					
		Radio	**TV**	**Extension officer**	**Social Media**	**Observation**	**NGOs**
Gender	*M.E*	.027	-.005	.031	.197	.168	-.002
	SE	.0364	.1341	.1069	.1267	.0982	.1331
Age	*M.E*	.001	-.006**	.001	.028*	.022*	.002
	SE	.0012	.0031	.0025	.0024	.0032	.0031
Total family	*M.E*	-.002	.019	-.020	-.033	-.013	.007
	SE	.0084	.0214	.0189	.0206	.0182	.0218
Education level	*M.E*	-.017	.083	.017	-.0170	-.070	.071
	SE	.0319	.0662	.0610	.0612	.0550	.0713
Farm size	*M.E*	.002	-.031	-.044	.020	-.015	-.023
	SE	.0128	.0260	.0243	.0216	.0217	.0274
Non-farm income	*M.E*	.001	.104	.136	-.000	-.019	.072
	SE	.0275	.1022	.0574	.0757	.0670	.0787
Communication devices	*M.E*	.115*	.246	.134	.363**	-.289**	.176
	SE	.0302	.0745	.0892	.1669	.1175	.1332
Distance to the market	*M.E*	.000	-.011	.002	-.006	.011	.0180
	SE	.0040	.0162	.0114	.0174	.0127	.0136
Access to credits	*M.E*	.024	.212	.114	.225**	.114	.129
	SE	.0277	.1317	.0609	.0805	.0669	.0843
Support extension agencies	*M.E*	.005	.234*	.226*	.040	.076	.288*
	SE	.0260	.0765	.0463	.0597	.0513	.0510
Prob > chi^2		0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Pseudo R^2		0.55	0.17	0.25	0.49	0.47	0.17
N of obs		173	173	173	173	173	173

*M.E: Marginal Effects, SE: Standard Error: *, **, = 99%, and 95%, confidence intervals, respectively.*

Access to credits or loans has a significant influence on the utilization of social media platforms as a climate information source. This implies that affordable loans increase the likelihood of the farmers using social media, as sources of information by 22.5% (Table 4.7). Access to credit can facilitate investments in technology and communication tools, such as smartphones or internet connectivity, which can provide greater access to information sources such as social media. The results were supported by the finding of Mittal *et al.* (2010) who argued that farmers with rich resources access information not only from traditional media but also from modern methods of delivering information like Social media. Moreover, age significantly influenced the use of personal observation, social media, and television to obtain useful climate information, thus, in line with Mittal (2016). This means that as farmers get older, the likelihood of them using personal observation and social media as sources of information increases by 2.2% and 2.8%, respectively, while television usage decreases by 0.6% (Table 4.7). This is because old farmers have long agricultural expertise, allowing them to perceive indicators and patterns more efficiently and may depend more on personal observation. The increase in social media use among older farmers may be explained by the recent expansion of digital platforms and technology adoption, whereas the decrease in television usage may be due to the shifting media landscape, as many farmers now prefer mobile sources, which they can access anywhere.

Access to communication devices also positively and significantly influenced the usage of radio and social media but negatively the usage of personal observation as sources of climate information. This means access to communication devices increases the probability of the farmers using radio and social media as sources of information by 11.5% and 36.3%, respectively, and reduces personal observation by 28.9% (Table 4.7). Mittal (2016) also found significant correlations between farmers' use of different sources of information like social media, television, and access to communication devices. The availability of communication devices such as mobile phones and radio gives farmers accessible and fast access to a wide range of information sources, increasing the chance of farmers using radio and social media as sources of climate information. This would give farmers real-time weather updates and related agricultural information, allowing them to be educated about climate change hazards and coping methods.

Access to agricultural advisory services, NGOs, and international agencies has also a significant correlation with the use of extension officers, television, and personal observation for climate information sources. This cooperates with Jenkins *et al.* (2011) who reported significant relationships between farmers' use of different climate information sources and receiving support from local and international agencies. Access to support increases the likelihood of the farmers using extension officers, television, and NGOs as sources of information by 23.4%, 22.6%, and 28.8%, respectively (Table 4.7). Increasing access to communication devices and support can improve farmers' access to information, and it can therefore result in better agricultural practices and more informed decision-making (Table 4.7).

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study's findings have shown how social and economic factors of farmers influence farmers' perception of climate crises. For example, gender, family size, and possession of cell phones and radio significantly correlated to how the farmers perceived climate hazards, showing that male farmers, farmers with larger families, and those owning communication devices were more likely to observe climate change consequences, unlike their counterparts. The size of farming land showed a significantly negative correlation with farmers' perception of climate conditions, indicating that farmers with larger farms were unlikely to perceive the consequences of climate crises than those with smaller farms. This highlights the importance of considering these factors when designing awareness campaigns and educational programs to enhance climate change understanding among farmers.

The results revealed that age and family size, negatively correlated with the adoption of diversification and input use. Marital status also correlated positively to the adoption of irrigation, improved varieties and negatively to off-farm employment. Further, access to agricultural advisories correlated with the use of improved crop varieties. Off-farm income, agricultural credit, and support from agricultural extension, NGOs, and international agencies positively related to the farmers' adaption to irrigation, using improved/resistant varieties, and input use and negatively correlated to the adoption of finding off-farm jobs. Rich farmers have a higher propensity to make investments in cutting-edge climate-smart technologies, enhancing their climate resilience.

Farmers' climate information access was also found to be correlated positively by gender, marital status, and level of education, but negatively influenced by the farm size. Married men with formal education backgrounds are more likely to get climate data relative to unmarried women with non-formal education. Distance to the nearest market and support from various agencies (including local NGOs and international organizations) are also positively related to climate information by the farmers in the Hiran region of Somalia. Proximity to the market and receiving support from agencies such as financial resources and training enhances the chance of the farmers getting information related to climate hazards. In regards to climate information sources, age, access to credits access, access to communication devices, and access to agricultural advisory services, NGOs, and international agencies correlated with access to different climate information sources, such as social media, extension officers, television, and personal observation, to farmers.

5.2 Conclusions

The study showed that the demographic features of farmers determine their perception of climate change. That is gender, marital status, family size, farm size, and access to communication devices significantly influence whether they perceive climate change effects. These play crucial roles in shaping farmers' perceptions, which in turn affects their decision-making processes, adoption of agricultural practices, and overall productivity. Understanding these influences is vital for creating policies, interventions, and programs that effectively address the needs and challenges faced by farmers.

The empirical findings have also shown that smallholder farmers' adaptation measures are influenced by a set of factors related to demographic- and institutional characteristics. Notably, age, total family, marital status, and non-farm income, show significant effects on farmers' adaptation measures. Additionally, access to credits, access to agricultural advisories, and support from various agencies (including NGOs and international organizations), also have a significant influence on how these farmers employ adaptive techniques. This highlights the rationale of factoring in a wide range of factors when designing and implementing effective adaptation policies and programs.

Education level, gender, marital status, farm size, proximity to the nearest market, agricultural advisory support services, NGOs, and international agencies influencing farmers' access to climate data. On the other hand, factors like age, access to credits, access to communication devices (e.g., mobile phones and radios), and agricultural advisory support services increase the probability of accessing climate information. This suggests that tailored approaches to disseminating climate information considering farmers' specific characteristics and available resources can enhance information accessibility and facilitate better decision-making concerning responding to climate change effects.

5.2 Recommendations

The federal government, *Hirshabelle* State, local NGOs, and international agencies are recommended to:

1. Create gender-sensitive agricultural programs and inclusive policy, improve access to communication devices, provide targeted training, and foster inclusive policy development. These strategies aim to address the unique needs of farmers, ensuring equitable access to resources and empowering them to make informed decisions, ultimately leading to more effective and inclusive agricultural outcomes.
2. Develop adaptation programs that consider the specific demographic characteristics of smallholder farmers. For instance, older farmers or those with larger families may require different types of support compared to younger farmers or those with smaller households. Programs should also consider the importance of marital status and non-farm income on farmers' capacity to adapt.
3. Strengthen and expand access to affordable credit for smallholder farmers, enabling them to invest in necessary adaptation measures and support initiatives that help farmers diversify their income sources, including non-farm activities. Diversification and credit can increase resilience by providing additional financial resources that farmers can use to invest in adaptation measures.
4. Invest in targeted educational programs to enhance farmers' understanding of climate information, and expand communication infrastructure in rural areas to ensure reliable and timely access to climate data for all farmers.

5.3 Areas for further studies

In light of the findings from this investigation, the following are suggested as requiring further research:

1. There is a need for research works that will address the factors limiting effective communications on climate change to the farmers in the region.
2. Investigation to determine challenges to small-scale farmers' implementation of adaptation strategies to consequences of climate hazards.
3. Undertake detailed research on climate resilience promoting projects and development programs in the area. This will inform institutions and the

government to develop sustainable and climate-smart projects for the area ensuring the sustainability of these projects.

REFERENCES

Achieng, M.A. (2017). Determinants of adoption of integrated soil fertility management strategies for maize production intensification in Embu county, Kenya, (Master's thesis, submitted to Kenyatta University, Nairobi, Kenya. Available: https://ir-library.ku.ac.ke/bitstream/handle/123456789/17929/Determinants%20of%20adoption.........pdf?isAllowed=y&sequence=1

Adebayo, A., Onu, J., Adebayo, E., & Anyanwu, S. (2012). Farmers' Awareness, Vulnerability, and Adaptation to Climate Change in Adamawa State, Nigeria. *British journal of arts and sciences*. 9. 2046-9578

Adesiji, G.B., Matanmi, B.M., Onikoyi, M. P., & Saka, M.A. (2012). Farmers' perception of climate change in Kwara State, Nigeria. *World Rural Observer;4(2):46-54*

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., Naess, L. O., Wolf, J., & Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, 93, 335–354

Adger, WN., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress Dev. Stud.,* 3: 179-195

Adimassu, Z., & Kessler, A. (2016) Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift Valley of Ethiopia. *Environ. Syst. Res. 5*, 13

Adolwa, I.S., Okoth, P.F., Mulwa, R.M., Esilaba, A.O., Mairura, F.S., & Nambiro, E., (2012). Analysis of communication and dissemination channels influencing the adoption of integrated soil fertility management in Western Kenya. *J. Agric. Educ. Ext.* 18, 71–86

Agesa, B., Onyango, C., Vincent, K., Onwonga, R., & Karuku, G. (2019). Climate Change Effects on Crop Production in Kenya: Farmer Perceptions and Adaptation Strategies. African Journal of Food, Agriculture, *Nutrition and Development*. 19. 14010-14042. DOI:10.18697/ajfand.84.BLFB1017

AGRA. (2017). *Africa agriculture status report: The business of smallholder agriculture in Sub-Saharan Africa.* From https://agra.org/wp-content/uploads/2017/09/Final-AASR-2017-Aug-28.pdf

Ahsan, F., Chandio, A. A., & Fang, W. (2020). Climate change impacts cereal crop production in Pakistan. *International Journal of Climate Change Strategies and Management*, *12*(2), 257–269. https://doi.org/10.1108/ijccsm-04-2019-0020

Alem, K., Kibebew, K., Jemma, H., Muktar, M., & Yosef, A. (2016). Farmers' perception towards climate change and their adaptation measures in Dire Dawa Administration, Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development*, 8(12), 269–283. https://doi.org/10.5897/jaerd2016.0800

Alexandratos, N., & Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision. *ESA working paper no. 12-03*. Rome, FAO

Ali, A., & Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*, *16*, 183–194. https://doi.org/10.1016/j.crm.2016.12.001

Altea, L. (2020). Perceptions of Climate Change and its Impacts: a Comparison between Farmers and Institutions in the Amazonas Region of Peru. *Clim. Development* 12 (2), 134–146.

Ambani, M. & Percy, F. (2012). Decision-making for climate-resilient livelihoods and risk reduction: A Participatory Scenario Planning approach. (*http://www.careclimatechange.org/files/adaptation/ALP_PSP_Brief.pdf*.

Amit, P. (2018). The Impact of Climate Change in Southeast Asia – IMF Finance & Development(n.d.)from:https://www.imf.org/external/pubs/ft/fandd/2018/09/southeast-asia-climate-change-and-greenhouse-gas-emissions-prakash.htm

Aravindakshan, S., Krupnik, T. J., Groot, J. C., Speelman, E. N., Amjath-Babu, T. S., & Tittonell, P. (2020). Multi-level socioecological drivers of agrarian change: Longitudinal evidence from mixed rice-livestock-aquaculture farming systems of Bangladesh. *Agricultural Systems*, *177*, 102695.

Arokoyo, T. (2005). ICT's Application in Agricultural Extension Service Delivery. In F. Adedoyin, *Agricultural Extension in Nigeria.* Ilorin: AESON

Asadu, A. N., Ozioko, R. I., & Dimelu, M. U. (2018). Climate change information source and indigenous adaptation strategies of Cucumber farmers in Enugu State, Nigeria. *Journal of Agricultural Extension*, *22*(2), 136–146. https://doi.org/10.4314/jae.v22i2.12.

Asafu-Adjaye, J. (2014). The economic impacts of climate change on agriculture in Africa. *Journal of African Economies*, 23(2)

Asayehegn, K., Temple, L., Sanchez, B., & Iglesias, A. (2017). Perception of climate change and farm level adaptation choices in central Kenya. *Cah. Agric.*, *26*, 1–10

Asfaw, A. & Admassie, A. (2004) The Role of Education on the Adoption of Chemical Fertilizer under Different Socioeconomic Environments in Ethiopia. *Agricultural Economics*, 30, 215-228. http://dx.doi.org/10.1111/j.1574-0862.2004.tb00190.x

Asrat, P., & Simane, B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus Watershed, NORTH-WEST ETHIOPIA. *Ecological Processes*, *7*(1), 2–13. https://doi.org/10.1186/s13717-018-0118-8

Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of Smallholder Farmers' adaptation strategies to the effects of climate change: Evidence from Northern Uganda. *Agriculture & Food Security*, *10*(1). https://doi.org/10.1186/s40066-020-00279-1

Ayal, D.Y., Tilahun, K., Ture, K., & Zeleke, T.T. (2021). Psychological dimensions of climate change: perceptions, collective efficacy, and responses in Berehet District, north Shoa, Ethiopia. *Climatic Change* 165, 32. https://doi.org/10.1007/s10584-021-03033-z

Bagamba, F., Bashaasha, B., Claessens, I., & Antle, J. (2012) Assessing climate change impacts and adaptation strategies for smallholder agricultural systems in Uganda. *Afr Crop Sci J.*20:303–16.

Balew, S., Agwata, J., & Anyango, S. (2014). Determinants of adoption choices of climate change adaptation strategies in crop production by small-scale farmers in some regions of central Ethiopia. *J. Nat. Sci.*, *4*, 78–93

Banful, AB., Nkonya, E., & Oboh, V. (2010). Constraints to fertilizer use in Nigeria. *International Food Policy Research Institute.*

Bawa, D., Ani, A., & Bzugu, P. (2014). Influence of Sources of Agricultural Information on Maize Farmers in Southern Borno, Nigeria. *New Media and Mass Communication*, 31:68-72.

Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder Farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture & Food Security*, *6*(1), 2–13.

Benhin J.K.A. (2006), CEEPA Discussion, 21. CEEPA, University of Pretoria, South Africa.

Bhatti, AU., & Khan, MM. (2012) *Review:* soil management in mitigating the adverse effects of climate change. *Soil Environ* 31:1–10

Boitt, M. K., Langat, F. C., & Kapoi, J. K. (2018). Geospatial agro-climatic characterization for assessment of potential agricultural areas in SOMALIA, AFRICA. *Journal of Agricultural Informatics*, *9*(3). https://doi.org/10.17700/jai.2018.9.3.479.

Bryan, E., De Pinto, A., & Ringler, C., (2012). Institutions for Agricultural Mitigation: Potential and Challenges in Four Countries. International Food Policy Research Institute (IFPRI)

Carty, T. (2017). *A climate in CRISIS: How climate change is making drought and humanitarian disaster worse in East Africa.* Oxfam Policy & Practice., from, https://policy-practice.oxfam.org/resources/a-climate-in-crisis-how-climate-change-is-making-drought-and-humanitarian-disas-620263/.

Challinor, A. J., Watson, J., Lobell, D. B., Howden, S. M., Smith, D. R., & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change, 4*(4), 287–291. https://doi.org/10.1038/nclimate2153.

Cheriotic, V.F., Saidu, O., & Bebe, B.O. (2012). Access to climate change information and support services by vulnerable groups in Semi-Arid Kenya for adaptive capacity development. *African Crop Science Journal*, 20 (2), 169-180.

Chukwuji, C., Nwabueze, T., Aliyu, G., Sayudi, S., Yusuf, Z., & Zakariya, J. (2019). Awareness, Access and Utilization of Information on Climate Change by Farmers in Zamfara State, Nigeria. *Library Philosophy and Practice (e-journal)*. 2106.

Cohn, AS., Newton, P., Gil, JD., Kuhl, L., Samberg, L., Ricciardi, V., Manly, JR., & Northrop, S. (2017). Smallholder agriculture and climate change. *Annu Revi Environ Resour*. https://doi.org/10.1146/annurev-environ-102016-060946.

Coulibaly, JY., Birachi, EA., Kagabo, D.M., & Mutua, M. (2017). Climate services for agriculture in Rwanda: Baseline survey report. CCAFS Working Paper no. 202. Copenhagen, Denmark: CGIAR Research Program on Climate Change, *Agriculture and Food Security (CCAFS)*.

Csoto, M. (2010). Information flow in agriculture- through new channels for improved effectiveness. *Journal of Agricultural Informatics*, 1:25-34

Dang, H., Elton, Li., Nuberg, I., & Bruwer, J. (2019). Factors influencing the adaptation of farmers in response to climate change: A review, *Climate, and Development,* 11(9), 765-774.

De Matos Carlos, S., da Cunha, D. A., Pires, M. V., & Do Couto-Santos, F. R. (2020). Understanding farmers' perceptions and adaptation to climate change: the case of Rio das Contas basin, Brazil. *GeoJournal* 85, 805–821.

Debra, A. O. (2021), *climate change adaptation information for improved agricultural productivity among smallholder farmers in lower eastern Kenya*. (Master's thesis, Submitted to the University of Embu, Kenya).

Derbile, E. K., Bonye, S. Z., & Yiridomoh, G. Y. (2022). Mapping vulnerability of Smallholder Agriculture in Africa: A vulnerability assessment of food crop farming and climate change adaptation in Ghana. *Environmental Challenges*, *8*, 100537.

Deressa, T. T., Rashid, M. H., Claudia, R., Tekie, A., & Mahmud, Y. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change* 19: 248–55.

Deressa, T., Hassan, RM., Alemu, T., Yesuf, M., & Ringler, C. (2008). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. Washington DC: *International Food Policy Research Institute*.

Deressa, TT., Hassan, RM., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J. Agric. Sci.* 149(1):23-31

Eckstein, D., Künzel, Vera., Schäfer, L., Winges, & Maik. (2018). GLOBAL CLIMATE RISK INDEX 2020. Who Suffers Most From Extreme Weather Events? Weather-Related Loss Events in 2018 and 1999 to 2018.

Edame, G.E., Ekpenyong, W.M. Fonta, & Duru, E.J.C. (2011), 'Climate Change, Food Security and Agricultural Productivity in Africa: Issues and Policy Directions', *International Journal of Humanities and Social Science*, Vol. **1** (21):205-223

Elia, E. (2013). Information dissemination for adaptation to climate change and variability in the agricultural sector: the case of Maluga and Chibelela villages, Central Tanzania. Ph.D. thesis. *Pietermaritzburg*: University of KwaZulu-Natal.

Esham, M., Garforth, C., (2013). Agricultural adaptation to climate change: Insights from a farming community in Sri Lanka. *Mitig Adapt Strateg Glob Chang*;18(5):535–49. https://doi.org/10.1007/s11027-012-9374-6.

Evaristo, E. S. & Emmanuel, F. E. (2020). Socio-demographic determinants of access to climate change information among tomato growing farmers in Mvomero district, Tanzania. *University of Dar es Salaam Library Journal* Vol 15, No 2

Fahad, S., & Wang, J. (2018). Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan. *Land Use Policy*, *79*, 301–309. https://doi.org/10.1016/j.landusepol.2018.08.018.

Falaki, A. A., Akangbe, J. A., & Ayinde, O. E. (2013). Analysis of climate change and rural farmers' perception in North Central Nigeria. *Journal of Human Ecology*, *43*(2), 133–140. https://doi.org/10.1080/09709274.2013.11906619

Falco, SD., Yesuf, M., & Kohlin, G. (2011). What adaptation to climate change? Evidence from the Nile Basin, Ethiopia. In: International conference on the economics of adaptation to climate change in LowIncome countries. *Ethiopian Development Research Institute and International Food Policy Research Institute*, Washington, DC.

FAO. (2008). *An introduction to the basic concepts of food security*. Food security Information for action. Practical guides. Accessed on 3/19/2022.

FAOSTAT & FSNAU, (2017). Risk Events Affecting Agriculture in Somalia, from 1980–2017, World Bank and Food Agricultural Organization. Accessed on 1/10/2022.

Federal Government of Somalia (2013). *Somalia National Adaptation Programs of Action to Climate Change,* Ministry of Natural Resources, Mogadishu-Somalia. Available at: https://unfccc.int/resource/docs/napa/som01.pdf. Accessed on 1/16/2022.

Federal Government of Somalia (2018). Somalia Recovery and Resilience Framework. https://recovery.preventionweb.net/media/95130/download?startDownload=20240830. Accessed on 30/8/2024

Federal Government of Somalia (2019) National Environment Policy. Available at: https://faolex.fao.org/docs/pdf/som207696.pdf. Accessed on 30/8/2024

Federal Government of Somalia (2020). Somalia National Climate Change Policy, 2020. https://moecc.gov.so/wp-content/uploads/2023/07/Somalia-National-Climate-Change-Policy.pdf. Accessed on 30/8/2024

Federal Government of Somalia (2022). Somalia's National Adaptation Plan (NAP) Framework. https://napglobalnetwork.org/wp-content/uploads/2022/11/napgn-en-2022-somalia-nap-framework.pdf. Accessed on 30/8/2024

Food Agricultural Organization and World Bank. (2018). *Rebuilding Resilient and Sustainable Agriculture in Somalia* (first, Vol. 1, pp. 1–177). Available at: https://documents1.worldbank.org/curated/en/781281522164647812/pdf/124651-REVISED-Somalia-CEM-Agriculture-Report-Main-Report-Revised-July-2018.pdf. Accessed on 1/21/2022.

Fosu-Mensah, B. Y., Vlek, P. L., & MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: A case study of Sekyedumase district in Ghana. *Environment, Development, and Sustainability*, *14*(4), 495–505. https://doi.org/10.1007/s10668-012-9339-7.

Fourment, M., Ferrer, M., Barbeau, G., & Quénol, H. (2020). Local Perceptions, Vulnerability and Adaptive Responses to Climate Change and Variability in a Winegrowing Region in Uruguay. *Environ. Manage.* 66 (4), 590–599.

Funatsu, B. M., Dubreuil, V., Racapé, A., Debortoli, N. S., Nasuti, S., & Le Tourneau, F.-M. (2019). Perceptions of Climate and Climate Change by Amazonian Communities. Glob. *Environ. Change* 57, 101923. https://doi.org/10.1016/j.gloenvcha.2019.05.007

Gbetibouo, GA. (2009). Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa, vol. 849. Washington DC: *International Food Policy Research Institute*.

Gebre, GG., Isoda, H., Amekawa, Y., & Nomura, H. (2019). Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia. *Womens Stud Int Forum*. https://doi.org/10.1016/j.wsif.2019.102264.

GIEWS (2020). Country Brief Somalia. Global information and early warning system on food and agriculture. Accessed 5/26/ 2022.

Hansen, J., Sato, M., & Ruedy, R. (2012). Perception of Climate Change. *Proc. Natl. Acad. Sci.* 109 (37), E2415–E2423 DOI: 10.1073/pnas.1205276109

Harvey, C. A., Saborio-Rodríguez, M., Martinez-Rodríguez, M. R., Viguera, B., Chain-Guadarrama, A., Vignola, R., & Alpizar, F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. *Agriculture & Food Security*, 7(1), 2–20. https://doi.org/10.1186/s40066-018-0209-x.

Hassan, RM., & Nhemachena, C. (2008) Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. *African J Agric Resour Econ*. https://doi.org/10.22004/ag.econ.56969

HIRPHA., M.H. (2018). Smallholder farmers' adaptation strategies to climate change in Adama district, Oromia region, Ethiopia, ((Master's thesis, submitted to Jimma University, Ethiopia)

Howlader, M. S., & Akanda, M. G. (2015). Coastal Farmer's Perception of Climate Change Effects on Agriculture at Galachipa Upazila under Patuakhali District of Bangladesh. *Global Journal of Science Frontier Research,* 15.

Hulme, M., Doherty, R., Ngara, T., New, M., & Lister, D. (2001). African climate change: 1900–2100, *climate research,* Vol. 17: 145–168, https://www.int-res.com/articles/cr/17/c017p145.pdf

Idoma, K. & Mamman, M. (2016). Access and Utilization of Climate Change Information and Support Services among Vulnerable Communities in Agatu L.G.A., Benue State, Nigeria. *Federal University Gusau International Journal of Science for Global Sustainability*, 2 (2), 46-63

Idrisa, Y. (2009). *Analysis of the Determinants of Soybean Production Technology Adoption by Farmers in Southern Borno, Nigeria.* A Ph.D. Thesis Submitted To the School of Postgraduate Studies, University of Maiduguri.

Ifejika S. C., Kiteme, B., Ambenje, P., Wiesmann, U., & Makali, S. (2009). Indigenous knowledge related to climate variability and change: Insights from droughts in semi-arid areas of former Makueni District, Kenya. *Climatic Change*, *100*(2), 295–315.

IPCC, (2001): Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.

IPCC, (2007): Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

IPCC, (2014): Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

IPCC, Masson-Delmotte, V., P., Zhai, H.O., Pörtner, D., & Roberts, (2018). Contributors to the IPCC Special Report on Global Warming of 1.5°C. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty In the Press.

IPCC. (2014). Climate change 2014: climate change 2014: Impacts, adaptation, and vulnerability. In Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.) *Part B: Regional aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change.*

Iwuchukwu, J. C., & Udoye, C. E. (2014). Climate change information needs of Pineapple farmers in Enugu State, Nigeria. *Journal of Agricultural Extension, 18*(1), 73–83. https://doi.org/10.4314/jae.v18i1.7.

Jama, O.M., Liu, G., Diriye, A.W., Yousaf, B., Basiru, I., & Abdi, A.M. (2020). Participation of civil society in decisions to mitigate environmental degradation in post-conflict societies: evidence from Somalia. *J. Environ. Plann. Manag.* 63 (9), 1695–1715.

Jenkins R., White D., Van Montfort X., & Mike B., A. (2011) Variability in photos of the same face. Cognition. 2011 Dec;121(3):313-23. doi: 10.1016/j.cognition.2011.08.001. Epub 2011 Sep 3. PMID: 21890124.

Jones, J.W., Hansen, J.W., Royce, F.S., & Messina, C.D. (2000). Potential benefits of Climate forecasting to agriculture Agriculture. *Ecosystems and Environment* 82, 169e184.

Juana, J. S., Kahaka, Z., & Okurut, F. N. (2013). Farmers' perceptions and adaptations to climate change in Sub-Sahara Africa: A synthesis of empirical studies and implications for public policy in African Agriculture. *Journal of Agricultural Science*, *5*(4). https://doi.org/10.5539/jas.v5n4p121

Kahimba, F.C., Sife, A.S., Maliondo, S.M.S., Mpeta, E.J., & Olson, J. (2015), Climate change and Food Security in Tanzania: Analysis of current knowledge and research gaps. Tanzania *Journal of Agricultural Sciences*, 14(1),21-33.

Kaliba, AR., Mazvimavi, K., Gregory, TL., Mgonja, FM., & Mgonja, M. (2018) Factors affecting adoption of improved sorghum varieties in Tanzania under information and capital constraints. *Agric Food Econ*;6(1):18. https://doi.org/10.1186/s40100-018-0114-4

Karki, S., Burton, P., & Mackey, B. (2020). The Experiences and Perceptions of Farmers about the Impacts of Climate Change and Variability on Crop Production: a Review. Clim. Development 12 (1), 80–95. https://doi.org/10.1080/17565529.2019.1603096

Kassie, BT., Rötter, RP., Hengsdijk, H., Asseng, S., Van-Ittersum, MK., Kahiluoto, H., & Van-Keulen, H. (2013). Climate variability and change in the Central Rift Valley of Ethiopia: challenges for rain-fed crop production. Climate Change & Agriculture Research Paper, *Journal of Agricultural Science*, Page 1 of 17. Cambridge University Press;

Kifle, T., Ayal, Desalegn & Mulugeta, M. (2022). Factors influencing farmers' adoption of climate-smart agriculture to respond to climate variability in Siyadebrina

Wayu District, Central highland of Ethiopia. *Climate Services*. 26. https://doi.org/10.1016/j.cliser.2022.100290

Kimaru-Muchai, S.W., Ngetich, F.K., Baaru, M., & Mucheru-Muna, M.W., (2020). Adoption and utilization of Zai pits for improved farm productivity in drier upper Eastern Kenya. *J. Agric. Rural Dev*. Tropics Subtropics 121, 13–22.

Knox, J., Hess, T., Daccache, A., & Wheeler, T. (2012). Climate change impacts crop productivity in Africa and South Asia. *Environmental Research Letters*, *7*(3) 034032. https://doi.org/10.1088/1748-9326/7/3/034032.

Kogo, B.K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environ Dev Sustain* 23, 23–43 https://doi.org/10.1007/s10668-020-00589-1

Kotir, J. H. (2011). Climate change and variability in Sub-Saharan Africa: A review of current and future trends and impacts on agriculture and food security. *Environment, Development and Sustainability,* 13(3), 587–605

Kristjanson, P., Jost, C., Vervoort, J., Ferdous, N., & Schubert, C. (2014). *Moving from Knowledge to Action: Blogging Research and outcome highlights*. Retrieved from https://cgspace.cgiar.org/handle/10568/52262

Kurukulasuriya, P., & Mendelsohn, R. (2008) Crop switching as a strategy for adapting to climate change. *Afr J Agric Resour Econ*. 2(1):105–26.

Lehner, F., & Stocker, T. F. (2015). From Local Perception to Global Perspective. *Nat. Clim* Change 5, 731–734. https://doi.org/10.1038/nclimate2660

Limantol, A., Keith, B., Azabre, B., & Lennartz, B. (2016). Farmers' perception and adaptation practice to climate variability and change: a case study of the Vea catchment in Ghana. SpringerPlus. 5. 830. https://doi.org/10.1186/s40064-016-2433-9.

Lipper, L., Thornton, P., Campbell, BM., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., & Hottle, R. (2014). Climate-smart agriculture for food security. *Nat Climate Change*. https://doi.org/10.1038/nclimate2437.

Lowder, SK., Skoet, J., & Raney., T. (2016). The number, size, and distribution of Farms, smallholder farms, and family farms worldwide. *World Dev*. https://doi.org/10.1016/j.worlddev.2015.10.041.

Ludi, E. (2009). *Climate change, water, and food security*. London: Overseas Development Institute.

Mabe, F. N., Sienso, G., & Donkoh, S. A. (2014). Determinants of choice of Climate Change Adaptation Strategies in northern Ghana. *Research in Applied Economics*, *6*(4), 75. https://doi.org/10.5296/rae.v6i4.6121

Maddison, D. (2006). *The Perception of Adaptation to Climate Change in Africa.* CEEPA. Discussion Paper No.10. *Centre for Environmental Economics and Policy in Africa.* Pretoria, South Africa: University of Pretoria.

Manda, J., Alene, A. D., Gardebroek, C., Kassie, M., & Tembo, G. (2016). Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia.*Journal of Agricultural Economics*, *67*, 130-153.

McCarthy, N., Lipper, L., & Zilberman, D. (2018). Economics of climate-smart agriculture: An overview. In Climate Smart Agriculture (pp. 31–47). *Springer, Cham.*

Mehmood, M. S., Li, G., Khan, A. R., Siddiqui, B. N., Tareen, W. U., Kubra, A. T., & Ateeq-Ur-Rehman, M. (2022). An evaluation of farmers' perception, awareness, and adaptation towards climate change: A study from Punjab province Pakistan. *Ciência Rural, 52*(3). https://doi.org/10.1590/0103-8478cr20201109.

Meinshausen, M., Meinshausen, N., Hare, W., Raper, SCB., & Frieler K. (2009). Greenhouse gas emission targets for limiting global warming to 2°C. *Nature* 458:1158–62

Melka, Y., Kassa, H., Ketema, M., Abebaw, D., & Schmiedel, U. (2015). The effect of drought risk perception on local people's coping decisions in the Central Rift Valley of Ethiopia. *J Dev Agric Econ;*7(9):292–302

Mittal, S., (2016). Role of mobile phone-enabled climate information services in gender-inclusive agriculture. Gender Technol. Dev. 20 (2), 200–217. https://doi.org/10. 1177/0971852416639772

Mittal, S., Gandhi, S., & Tripathi, G. (2010). Socio-Economic Impact of Mobile Phone on Indian Agriculture. ICRIER Working Paper No. 246. International Council for Research on International Economic Relations, New Delhi.

Morton, JF. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proc Natl Acad Sci.* https://doi.org/10.1073/pnas.0701855104.

Mtega, W.P. (2012). Access to and usage of Information among Rural Communities: a Case Study of Kilosa District Morogoro Region in Tanzania. *The Canadian Journal of Library and Information Practice and Research,* 7(1) https://doi.org/10.21083/partnership.v7i1.1646

Mudombi, S., Nhamo, G., & Muchie, M., (2014). Socio-economic determinants of climate change awareness among communal farmers in two districts of Zimbabwe. *African Insight* 44 (2), 1–15.

Muema, E., Mburu, J., Coulibaly, J., & Mutune, J. (2018). Determinants of access and utilization of seasonal climate information services among smallholder farmers in Makueni COUNTY, KENYA. *Heliyon*, *4*(11). https://doi.org/10.1016/j.heliyon.2018.e00889.

Mugi-Ngenga, E. W., Mucheru-Muna, M. W., Mugwe, J. N., Ngetich, F. K., Mairura, F. S., & Mugendi, D. N. (2016). Household socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. *Journal of Rural Studies*, *43*, 49-60

Mwalukasa, N. (2013). Agricultural information sources used for climate change adaptation in Tanzania. *Library Review*, 62 (4), 66-292 https://doi.org/10.1108/LR-12-2011-0096.

Mwaniki, F. (2016). Kenyan farmers' perceptions of and adaptations to climate change before and after a radio program intervention. Ph.D. thesis, James Cook University.

Naanwaab, C., Yeboah, O. A., & Kyei, F., Sulakvelidze, A., & Goktepe, I. (2014). Evaluation of consumers' perception and willingness to pay for bacteriophage-treated fresh produce. Bacteriophage. 4(4)e979662 DOI:10.4161/21597081.2014.979662.

Nanjappan, B, & Parameswaranaik, J. (2019). Factors Affecting the Perception of Farmers about Climate Change in Agriculture.

Ndamani, F., & Watanabe T. (2016). Determinants of farmers' adaptation to climate change: A micro-level analysis in Ghana. *Sci Agri.*73(3):201–8. https://doi.org/10.1590/0103-9016-2015-0163

Ndambiri, H., Ritho, C., & Mbogoh, S. (2014). An evaluation of farmers' perceptions of and adaptation to the effects of climate change in Kenya. *International Journal of Food and Agricultural Economics*. 1. 75-96. ISSN 2147-8988.

Nhemachena, C., & Hassan, R. (2007). Micro-level analysis of farmers' adaptation to Climate change in Southern Africa. IFPRI Discussion Paper No. 00714. *International Food Policy Research Institute*, Washington, D.C

Niang, I., O. C., Ruppel, M. A., Abdrabo, A., Essel, C., Lennard, J., & Padgham. (2014). Africa. Pp. 1199–1265 *in* V. R., Barros, C. B., Field, D. J., Dokken, M. D., Mastrandrea, K. J., Mach, T. E., Bilir, M., Chatterjee, K. L., Ebi, Y. O., Estrada, R. C., Genova, B., Girma, E. S., Kissel, A. N., Levy, S., MacCracken, P. R., Mastrandrea, L. L., White, eds. *Climate change 2014: impacts, adaptation, and vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge Univ. Press, Cambridge, United Kingdom and New York, NY.

Nicholls RJ., & Cazenave A. (2010). Sea-level rise and its impact on coastal zones. Science. 18;328(5985):1517-20. doi: 10.1126/science.1185782. Erratum in: Science. 2010 Aug 6;329(5992):628. PMID: 20558707.

Notenbaert A., Lannerstad, M., Herrero, M., Fraval, S., Ran, Y., Paul, B., Mugatha, S., Barron, J. & Morris, J. (2014). A framework for environmental ex-ante impact assessment of livestock value chains. Paper presented at the 6th All Africa Conference of Animal Agriculture, Nairobi, 29 October 2014. Nairobi: International Center for Tropical Agriculture

Nwangi, M., & Kariuki, S. (2015) Factors determining the adoption of new agricultural technologies by smallholder farmers in developing countries. *J Econ Sustain Dev* 6:208–216

Odari, C. A. (2018). *Adaptation to climate variability by smallholder dairy farmers in Nyandarua County, Kenya.* (Master thesis submitted to the School of Environmental Studies of Kenyatta University, Kenya)

Ojo, T. O., & Baiyegunhi, L. J. S. (2020). Determinants of climate change adaptation strategies and their impact on the net farm income of rice farmers in southwest Nigeria. *Land Use Policy*, *95*, 103946. https://doi.org/10.1016/j.landusepol.2019.04.007

Okeyo, S.O., Ndirangu, S.N., Isaboke, H.N., Njeru, L.K., & Omenda, J.A., (2020). Analysis of the determinants of farmer participation in sorghum farming among small-scale farmers in Siaya County, Kenya. *Sci. Afr.* 10, e00559

Okonya, J. S., Syndikus, K., & Kroschel, J. (2013). Farmers' perception of and coping strategies to climate change: Evidence from SIX Agroecological zones of Uganda. *Journal of Agricultural Science*, *5*(8), 252–263. https://doi.org/10.5539/jas.v5n8p252.

Okoro, J. C., Agwu, A. E., & Anugwa, , I. Q. (2016). Climate change information needs of rural farmers in Enugu state. *Journal of Agricultural Extension*, 20(2), 215–232. https://doi.org/10.4314/jae.v20i2.16.

Oladele, O.I. (2006). Multilinguality of farm broadcast and agricultural information access in Nigeria. *Nord. J. Afr. Stud. 15*, 199–205.

Oluwatusin, F. M. (2014). The perception of and adaptation to climate change among Cocoa Farm households in Ondo State, Nigeria. *Academic Journal of Interdisciplinary Studies*. DOI: 10.5901/ajis.2014.v3n1p147

Orduño, M., Kallas, Z., & Ornelas, H., S. (2019). Analysis of Farmers' Stated Risk Using Lotteries and Their Perceptions of Climate Change in the Northwest of Mexico. *Agronomy* 9 (1), 4. https://doi.org/10.3390/agronomy9010004

Oyekale, A. (2012). Impact of Climate Change on Cocoa Agriculture and Technical Efficiency of Cocoa Farmers in South-West Nigeria. *Journal of Human Ecology. 40. 143-148.* DOI:10.1080/09709274.2012.11906532

Oyekale, A. S. (2015). Factors explaining farm households' access to and utilization of extreme climate access in Sub-Saharan Africa (SSA). *Environmental Economics*, 6(1), 91-103

Pichi-Sermolli, R.E.G. (1957). Una carta geobotanica dell'Africa Orientale. *Webbia* 8, 129 pp

Popoola, O. O., Monde, N., & Yusuf, S. F. (2019). Climate change: Perception and adaptation responses of poultry smallholder farmers in Amathole District Municipality, Eastern Cape Province of South Africa. *South African Journal of Agricultural Extension (SAJAE)*, *47*(3).

Popoola, O., Yusuf, F., & Monde., N. (2020). Information Sources and Constraints to Climate Change Adaptation amongst Smallholder Farmers in Amathole District Municipality, Eastern Cape Province, South Africa. *Sustainability*. 12. 5846. https://doi.org/10.3390/su12145846.

Qin, DH. (2015). China National Assessment Report on risk management and adaptation of climate change. *Science Press,* Beijing (in Chinese).

Ramirez-Villegas, J., & Thornton, P.K. (2015). *Climate change impacts African crop production.* CCAFS Working Paper no. 119. Copenhagen, Denmark: CGIAR Research Program on Climate Change, *Agriculture and Food Security* (CCAFS).

Rehman, F., Muhammad, S., Ashraf, I., Ch, K.M., & Ruby, T. (2013). Effect of farmers' socio-economic characteristics on access to agricultural information: Empirical evidence from Pakistan. *J. Anim. Plant Sci.* 2013, *23*, 324–329

Roco, L., Engler, A., Bravo-Ureta, B. E., & Jara-Rojas, R. (2015). Farmers' Perception of Climate Change in Mediterranean Chile. *Reg. Environ. Change* 15 (5), 867–879. https://doi.org/10.1007/s10113-014-0669-x

Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., Boote, K. J., Folberth, C., Glotter, M., Khabarov, N., Neumann, K., Piontek, F., Pugh, T. A., Schmid, E., Stehfest, E., Yang, H., & Jones, J. W. (2013). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. *Proceedings of the National Academy of Sciences, 111*(9), 3268–3273. https://doi.org/10.1073/pnas.1222463110.

Sanog, K., Binam, J., Bayala, J., Villamor, G.B., Kalinganire, A., & Dodiomon, S. (2012) Farmers' Perceptions of Climate Change Impacts on Ecosystem Services Delivery of Parklands in Southern Mali. *Agroforestry Systems*, 1-17.

Simelton, E., Quinn, C. H., Batisani, N., Dougill, A. J., Dyer, J. C., Fraser, E. D. G. (2013). Is Rainfall Changing? Farmers' Perceptions, Meteorological Data, and Policy Implications. *Clim. Development* 5, 123–138. https://doi.org/10.1080/17565529.2012.751893

Singh, C., Kituyi, E., & Urquhart, P. (2016). From pilots to systems: Barriers and enablers to scaling up the use of climate information services in smallholder farming communities. CARIAA Working Paper # 3. Collaborative adaptation research initiatives in Africa and Asia, *IDRC*, Ottawa, Canada. Available at: https://www.ccardesa.org/knowledge-products/pilots-systems-barriers-and-enablers-scaling-use-climate-information-services

Smit, B., & Pilifosova, O. (2003). Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development*, 8(9), 9. Retrieved:
from https://sustainabledevelopment.un.org/content/documents/1490adaptation_paper.pdf. Accessed on 5/01/2022.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity, and vulnerability. *Global Environmental Change, 16*(3), 282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Sofoluwe N. A., Tijani A. A., & Baruwa O. I. (2011). Farmers' perception and adaptation to climate change in Osun State, Nigeria. *African Journal of Agricultural Research* Vol. 6(20), pp. 4789-4794. https://doi.org/10.5897/AJAR10.935

Sonny, N., Domingo, A.D., Agbon, Ma., Divina, O., Anna, J. L., Umlas, K., Mae, C. Z., & Celia M. R. (2020). Barriers to the application of weather and climate information in smallholder vegetable farming in Benguet. Discussion Papers, Availableat:https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidsdps2014.pdf

Sultan, B., & Gaetani, M. (2016). Agriculture in West Africa in the twenty-first century: Climate change and impacts scenarios and potential for adaptation. *Frontiers in Plant Science, 7,* 20. https://doi.org/10.3389/fpls.2016.01262.

Suvedi M, Ghimire R, & Kaplowitz M. (2017) Farmers' participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis. *J Agric Educ Ext.*;23(4):351–71. https://doi.org/10.1080/1389224X.2017.1323653.

Tenge, De., Graaff, J., & Hella, J.P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. *Land Degradation and Development* 15 (2), 99–114.

Tesso, G., Emana, B., & Ketema, M. (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. *Int. Res. J. Agric. Sci. Soil Sci.* 2(8):347-363

The United Nations Population Fund (UNFPA) (2014). The Population Estimation Survey (PESS) for Somalia. Available on: https://somalia.unfpa.org/sites/default/files/pub-pdf/Population-Estimation-Survey-of-Somalia-PESS-2013-2014.pdf. Accessed on 1/20/2022.

The World Bank (2007). Washington, D.C: World Bank Group. http://documents.worldbank.org/curated/en/732761468779449524/The-World-Bank-annual-report-2007

The World Climate Research Programme Accomplishment Report. (2012). Retrieved June 26, 2022, from https://www.wcrp climate.org/images/documents/reports_flyers/WCRP_report03_2012.pdf

Thompson, H. E., Berrang-Ford, L., & Ford, J. D. (2010). Climate change and food security in sub-Saharan Africa: A systematic literature review. *Sustainability, 2*(8), 2719–2733.

Thornton P.K., Jones P.G., Alagarswamy G., & Andresen J. (2009) Spatial variation of Crop yield response to climate change in East Africa. *Global Environmental ChangeHuman and Policy Dimensions* 19:54–65.

Uddin, M. N., Bokelmann, W., & Dunn, E. S. (2017). Determinants of farmers' perception of climate change: A case study from the coastal region of Bangladesh. *American Journal of Climate Change*, *06*(01), 151–165. https://doi.org/10.4236/ajcc.2017.61009. Accessed on 11/15/2021.

UNFCCC. (2015). *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015. Addendum Part Two: Action taken by the Conference of the Parties at its twenty-first session. CCC/CP/2015/10/Add.1. Paris, 30 November–11 December 2015.* Retrieved April 28, 2021: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

Van den Ban, A.W., & Hawkins, H.S. (2000). Agricultural Extension. 2nd Edition, *Blackwell Science*, UK.

Van der Linden, S. (2015). The Social-Psychological Determinants of Climate Change Risk Perceptions: Towards a Comprehensive Model. *J. Environ. Psychol.* 41, 112–124. https://doi.org/10.1016/j.jenvp.2014.11.012

Venema, J.H., & Vargas, R. (2007). *Land suitability assessment of the Juba and Shabelle riverine areas in Southern Somalia.* FAO-SWALIM. Project Report No. L-09. Nairobi, Kenya.

Vermeulen, SJ., Aggarwal, PK., Ainslie, A., Angelone, C., Campbell, BM., Challinor, AJ., Hansen, JW., Ingram, JSI., Jarvis, A., Kristjanson, P., & Lau, C. (2012). Options for support to agriculture and food security under climate change. *Environ Sci Policy*. https://doi.org/10.1016/j.envsci.2011.09.003

Viola, C., Kirui, M., & Waiganjo, S. C. (2014), Communicating climate change adaptation strategies: climate-smart agriculture information dissemination pathways among smallholder potato farmers in Gilgil Sub-County, Kenya, *International Journal of Advanced Research*, Volume 2, Issue 9, 44-53

Vorley B, Lundy M, MacGregor., J. (2009). Business models that are inclusive of small farmers. Agro-industries for Development, Wallingford, UK: CABI for FAO and UNIDO. p. 186–222.

Waaben, A., Habimana, D., Joshi, I., & Mumuli, S. (2020) Uncovering the challenges of domestic energy access in the context of weather and climate extremes in Somalia. *Weather Clim Extremes* 27:100185. https://doi.org/10.1016/j.wace.2018.09.002.

Warsame, A. A., Sheik-Ali, I. A., Ali, A. O., & Sarkodie, S. A. (2021). Climate change and crop production nexus in Somalia: An empirical evidence from ARDL technique. *Environmental Science and Pollution Research*, *28*(16), 19838–19850. https://doi.org/10.1007/s11356-020-11739-3.

Whitmarsh, L., & Capstick, S. (2018) "Perceptions of Climate Change," in Psychology and Climate Change: Human Perceptions, Impacts, and Responses. Editors S. Clayton and C. Manning. *Academic Press*: 13–33. https://doi.org/10.1016/B978-0-12-813130-5.00002-3

Wiid, N., & Ziervogel, G. (2012). Adapting to climate change in South Africa: Commercial farmers' perception of and response to changing climate. *South African Geographical Journal*, *94*(2), 152–173. https://doi.org/10.1080/03736245.2012.742783

Xie, W., Huang, J., Wang, J., Cui, Q., Robertson, R., & Chen, K. (2018). Climate change impacts on China's Agriculture: The responses from market and trade. *China Economic Review*, *62*, 4–32. https://doi.org/10.1016/j.chieco.2018.11.007

Yamane, T. (1967). Statistics: An Introductory Analysis, 2nd Edition, New York: *Harper and Row.*

APPENDICES

Appendix i: Questionnaire

My name is Abdiwali Abdulle Odawa I am writing a thesis entitled "Smallholder Farmers' Adaptation Strategies to Climate Change Effects in Hiran Region, Somalia" in partial fulfillment for an MSc in Environmental Science. This research, without a certain, will make a substantial contribution to reducing the climate change-related challenges that farmers in the Hiran region, face. As a result, your valuable participation in reaching the research's goal by providing reliable information is extremely valuable. I will only use the information we collect from you for academic purposes and will keep it private. As a result, please do not hesitate to provide accurate information.

I appreciate your cooperation in advance.

General Directions

Put (x) marks in the space provided for closed-ended questions.

Part I. Supportive Information

i. Name of interviewer: ....

ii. Name of respondent..

iii. Name of Village: ....

Kindly tick (✓) the boxes as you go

SECTION-A

SOCIO-ECONOMIC AND INSTITUTIONAL CHARACTERISTICS

1. Gender of the respondent: Male ☐ Female ☐
2. Age of the respondent (in years)..............................
3. Number of total family members:..............................
4. Marital status: Married ☐ Unmarried ☐
5. Education level: Formal Education ☐ No formal education ☐
6. Farming experience of the respondent...................................
7. Farm size in Hector...
8. What is your mean monthly household income (In USD)..............................
9. Do you or any family members get money from sources other than farming?

Yes ☐ No ☐

10. Farming system: Crop production only ☐ Livestock rearing only ☐

Mixed farming ☐

11. How did you acquire your land? Inherited ☐ Purchased ☐

Rented ☐

12. Do you own any media equipment for communication, such as a TV, radio, cell phone, etc.?

Yes ☐ No ☐

13. 13. If the answer is "yes," what kinds of electronic devices do you own?................

14. How far away is the market from which you purchase your farming supplies (such as fertilizers, seeds, and hoes)?

Etc) (IN KM)?..

15. When faced with a financial crunch, do you have recourse to any official credits?

Yes ☐ No ☐

16. Are agricultural extension services available in your village?

Yes ☐ No ☐

17. Does the agricultural extension provide you with any assistance that could help you enhance your farming operations? Yes ☐ No ☐

SECTION-B

PERCEPTION OF FARMERS ON CLIMATE CHANGE

18. Over the past 20 years, have you noticed any permanent shifts in the climate factors (especially temperature and rainfall)?

Yes ☐ No ☐

19. If yes indicate (✓) what has been the change.

s/n	Long-term change in mean climate variables	Selected factor (✓)
1	Increased Temperature	
2	Decreased temperature	
3	Increased rainfall duration	
4	Decreased rainfall duration	
5	Increased rainfall intensity	
6	Decreased in rainfall intensity	

SECTION-C

FARMERS ADAPTATION MEASURES

20. Have you responded to climate change by implementing any adaptation strategies to lessen its effects?

Yes ☐ No ☐

21. If your answer is yes. Have you adapted the following adaptation strategies to your farm? [Indicate (✓)]

No	Adaptation Measures	Yes	No
1	Crop diversification		
2	Irrigation		
3	Planting an early maturing crop		
4	Soil and water management		
5	Minimum soil tillage		
6	Use improved/resistant variety.		
7	Find off-farm employment		
8	Input use (seeds or fertilizers)		

SECTION-D

ACCESS TO CLIMATE INFORMATION AND SOURCES

22. Do you have access to climate information? Yes ☐ No ☐

23. If you accessed climate information what is the source of that information? [Indicate (✓)]

No	**Sources of climate change information**	**Yes**	**No**
1	Radio		
2	TV		
3	Agricultural Extension officer		
4	Social Media		
5	Personal observation		
6	NGOs and international agencies		

THANK YOU……….

Appendix ii: Higher Education Department and Culture Permit

JAMHUURIYADDA FEDERALKA SOOMAALIYA
WasaaraddaWaxbarashada,HiddahaiyoTacliintaSare
Waaxda Tacliinta Sare & Hiddaha

جمهورية الصومال الفيدرالية
وزارة التربية والثقافة والتعليم العالي
قطاع عام التعليم العالي والثقافة

Agaasimaha Guud eeTacliinta sare

Somali Federal Republic
Ministry Of Education, Culture & Higher Education
Higher Education Department and Culture

Ref: WWHTS/TS/0006/2024 **Date: 16/01 /2024**

TO WHOM IT MAY CONCERN,

SUBJECT: PERMISSION LETTER OF RESEARCH

Dear: Mr. Abdiwali Abdulle Odawa

Following your application dated 08 January 2024. Regarding the authority to carry research on: **"Smallholder Farmers' Adaptation Strategies to Climate Change Effects in Hiran Region, Somalia."**

The Ministry of Education Culture and Higher Education is very pleased to inform that you are fully authorized to carry out research in the location Hiran Region of Somalia, from the date signed this later you can go ahead to carry out all your topic research activation on ethical manner in the area mentioned above.

You're advised to report the above-mentioned direction communication and direct education officers before you start the work after you have done it. We really appreciate the good work that you have done during the course work.

Your sincerely

Mohamed Abdullahi Mohamud
DIRECTOR GENERAL OF HIGHER EDUCATION AND CULTURE

Tel: +25261-5555585
E-mail: highereduction@moe.gov.so Website: www.moesomalia.net

Appendix iii: Graduate School Research Proposal Approval

KENYATTA UNIVERSITY
OFFICE OF THE EXECUTIVE DEAN GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Executive Dean, Graduate School **DATE: 31st May 2023**

TO: Mr. Abdiwali Abdulle Odawa **REF: N50F/27939/2019**
C/O Department of Environmental Sciences and Education

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board, at its meeting on **22nd May 2023**, approved your Research Proposal for the M.Sc. Degree entitled, ***"Smallholder Farmers' Adaptation Strategies to Climate Change and Access to Climate Information in Hiran Region, Somalia."***

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking and Progress Report Forms per semester. The Forms are available at the University's Website under Graduate School webpage downloads.

Also, please ensure that you publish article(s) from your thesis before submitting it to Graduate School for examination as per the Commission for University Education and Kenyatta University guidelines.

Thank you.

DR. HARRIET ISABOKE
FOR: EXECUTIVE DEAN, GRADUATE SCHOOL

cc. Chairman, Department of Environmental Sciences and Education

Supervisors:

1. Prof. Monicah Mucheru- Maina
C/o Department of Environmental Sciences and Education
Kenyatta University

2. Dr. Benson Kamau Mburu
C/o Department of Environmental Sciences and Education
Kenyatta University