# EVALUATING FACTORS INFLUENCING FARMERS' ACCESS AND WILLINGNESS TO PAY FOR CLIMATE CHANGE ADAPTATION INFORMATION IN SOUTH-EASTERN KENYA

**SAMUEL ODIKOR**

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## DECLARATION

This thesis is my original work and has not been submitted for the award of a degree in any other University.

Samuel Odikor Date: ……6th June 2023…….

This thesis has been submitted with our approval as university supervisors

Signature: …… …… Date: ……6th June 2023…………….

Dr. Hillary T. Nyang'anga

Department of Agricultural Economics

University of Nairobi

Signature: Date: 6th June.2023…………………….

Dr. Kizito M. Kwena

Kenya Agricultural and Livestock Research Organization (KALRO)

## DEDICATION

This thesis is dedicated to my late father Mr. Jackson Ishmael Masake Laini, mother Robina Betty Aboo, and daughters Jenna Janice Osapir and Jasmine Jessa Aboo.

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## List of Abbreviations and Acronyms

AIC – Akaike Information Criteria

ASALS – Arid and Semi-Arid Lands

CBO – Community Based Organization

CCA – Climate Change Adaptation

CFS – Climate Field Schools

CHAI – Climate Change Adaptation Information

CVM – Contingent Valuation Method

FAO – Food and Agriculture Organization of the United Nations

ICT – Information Communication Technology

IMF – International Monetary Fund

IDRC – International Development Research Centre

IPCC – International Panel for Climate Change

KMD – Kenya Meteorological Department

KMO – Kaiser-Meyer-Olkin Test

KNBS – Kenya National Bureau of Statistics

MoALF – Ministry of Agriculture, Livestock, Fisheries and Cooperatives

NCCA – National Climate Change Action

NCPB – National Cereals Produce Board

NGO – Non-Governmental Organization

ODK – Open Data Kit

PCA – Principal Component Analysis

SDG – Sustainable Development Goal

SPSS – Statistical Package for Social Science

TCO – Total Cost of Ownership

UNESCO – United Nations Education Scientific and Cultural Organization

UNFCCC – United Nations Framework Conventions on Climate Change

USD – United States Dollar

WMO – World Meteorological Organization

WTP – Willingness to Pay

# ABSTRACT

Currently, the biggest threat to global agricultural productivity is climate change. In order to ensure agricultural production and reduce food poverty, farmers must adapt to this new state. Access to adaptation information to enable them plan their agricultural investments was of paramount importance. This study sought to assess factors that influenced farmers' access to climate change adaptation information and their willingness to pay as they seek to achieve resilience in the face of changing climatic conditions. The study adopted a qualitative research approach where data was collected firsthand by interviewing 443 smallholder farmers. The factors influencing farmers' access to information on coping with climate change and their willingness to pay were examined using the Probit Regression Analysis Model. From the study, the findings revealed that majority of the farmers accessed climate change adaptation information through a cocktail of channels. Radio, farmer groups, mobile phones, workshops, pamphlets, agricultural extension service providers constituted the main channels of information access. Household characteristics such as education level, group membership, awareness of adaptation, access to communication media significantly influenced access to the information. The effectiveness of the dissemination channel ultimately influenced the access to the information transmitted therein. On Willingness to Pay (WTP), 77.2% of the farmers were willing to pay to access or gain knowledge on adaptability, 62% of which were willing to pay in Cash. The mean willingness to pay in Cash was 12.78 USD per year whereas payment in Kind was dominantly through giving of maize yield from the production of 66.97 kgs per year which translated to 18.40 USD at current market price. This amount was contrasted on smallholder average annual income of Ksh. 50, 200 (460 USD). The main factors that affected farmers' WTP were the efficiency, understanding, and accessibility to information on adaptation to the changing climate. Farmers that had advanced in years and rely on farming as the primary income source were reluctant to pay for the information. Further sensitization of farmers on importance of climate change adaptation should be conducted. Similarly, farmers should be encouraged to join the climate field schools for more edification on climate change adaptation. Information dissemination source should adopt channels that can reach larger population on time and effectively.

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background

The greatest challenge to enhanced agricultural production globally is unquestionably climate change. It comes from continued emissions and an increase in the atmospheric concentration of greenhouse gases. Due to global warming, rainfall patterns have been altered, resulting in more frequent and severe occurrences including droughts, floods, forest fires, and landslides, particularly in sub-Saharan Africa (Hansen et al., 2013; Masson-Delmotte et al., 2018; World Meteorological Organization, 2021a). Attaining agricultural sustainability required to eradicate poverty and guarantee food security is now a big challenge in Kenya and entire sub-Saharan Africa because of these climate shocks. The challenge is bigger among smallholder farmers in the arid and semi-arid areas due to their vulnerability and low adaptive capacity (Rapholo and Diko Makia, 2020; Kalele *et al.*, 2021; Quandt, 2021). Adaptation and mitigation strategies must be developed to enable farmers in these regions (Rao et al., 2011; Omoyo, Wakhungu, and Oteng'i, 2015; Mugi-ngenga et al., 2016; Panda and Shivamurthy, 2018).

The International Panel on Climate Change states that the most practical strategies for farmers to reduce and adapt to climate change are proactive decision-making, crop and livestock insurance, which will ensure compensation in the event of crop failure or livestock loss due to climate change (IPCC, 2019). However, due to financial limitations, crop and livestock insurance are not practical for the majority of smallholder farmers in SSA. Generally, adaptation is essential due to the high rates of poverty among farmers as well as the enormous uncertainty around the effects and scale of climate change (Gyimah et al., 2020; Makate et al., 2019; Mugi-ngenga et al., 2016).

The smallholder farmers adaptability to climate change is influenced by a variety of factors, including access to information about it, education level, age, household size, marital status, gender of household head, and social networks within the community (Gebru et al., 2018; McGahey & Lumosi, 2018; Panda & Shivamurthy, 2018, Opiyo et al., 2016; Othieno, 2014). These factors vary between individuals, communities, countries, and regions. Access to climate change adaptation information enabled farmers to make proactive and tactical decisions as far as farm investments were concerned, thus, minimizing losses while maximizing opportunities presented by climate change (Otitoju and Enete, 2016; Zolnikov, 2019; Al-amin, Masud and Sarkar, 2020; Locatelli et al., 2020).

In most developing countries such as Kenya, dissemination of this information is mostly done by government agencies (21%) through funded projects, private organizations - 27%, Non-Governmental Organizations (NGOs) – 21%, Community-Based Organizations (CBOs) -17 and International Organizations (14%) (World Bank, 2021). This demonstrates that efforts are in place to enable farmers to have access to reliable information.

Based on this context, the Canadian International Development Research Centre (IDRC) funded a regional project called "The last mile: Up-scaling Climate Information Services to Build Community Resilience in Uganda and Kenya" that aimed to use information and communication technologies to provide downscaled climate change adaptation information to farmers in Machakos, Makueni, and Kitui Counties. The goal of the Climate Change Adaptation and ICT (CHAI) project was to better understand how communities and individuals could be empowered to use ICT tools to increase farmers' ability to respond to climate-related difficulties.

To accomplish this, the project implemented a mechanism for disseminating information that makes use of a variety of channels, including mobile phones, farmer magazines, pamphlets, print media, and conventional techniques like the use of agricultural extension service providers and local FM radio stations within the three counties, such as Climate Field Schools (CFS).

The climate change adaptation information disseminated included weather-based advisory on appropriate soil and water management practices, responsive/appropriate agronomic practices, pest and disease control measures, market opportunities, post-harvest management techniques as well as appropriate crop varieties. An advisory that is considered suitable for climate change adaptation (Umunakwe and Nnadi, 2014; Gebru *et al.*, 2015, 2018; Lumosi *et al.*, 2016; Mugi-ngenga *et al.*, 2016; McGahey and Lumosi, 2018). The advisory is based on seasonal forecasts provided by Kenya Meteorological Department (KMD).

## 1.2. Statement of the Problem

Agriculture used to be influenced by a bid and/or a demand, but today it is influenced by information. To enable consumers to seize chances and reap benefits, new information must quickly reach them (Milovanovi, 2014; Amwata, Omondi, and Kituyi, 2018). Particularly in the ASALs of Kenya, this aspect of climate change adaptation information varies greatly from year to year and from location to location.

Many studies have been conducted on adoption processes and climate information services and their impact on agriculture in developing countries (Takahashi, Muraoka, and Otsuka, 2020; Mogaka and Muriithi, 2021). Adaptation strategies have been promoted to enhance farming enterprises' resilience to climate change; it has been noted that farmers are hesitant to invest in these strategies thus affecting agricultural productivity and livelihoods (Yvonne et al., 2016; Muema et al., 2018; Mutunga, Ndungu, and Muendo, 2018; Mogaka and Muriithi, 2021; Muriithi et al., 2021). This has left the need to promote adaptation measures inevitable. With the widespread existence of climate information services, climate change adaptation information remains inadequate. Similarly, access to location-specific information is a challenge. This has limited the ability of farmers to make crucial farm decisions to minimize the negative effects or exploit the opportunities of climate change. A limited effort has been put to determine the reach and value of this information to farmers in the counties of Machakos, Kitui and Makueni (Yvonne *et al.*, 2016; Onyango *et al.*, 2021).

Despite climate change adaptation information having been disseminated among smallholder farmers in these regions, the perceptions of farmers towards the information or medium of dissemination is not clear. Similarly, the economic value the farmers attach to the information has not been demonstrated.

## 1.3. Objectives

### 1.3.1. Overall objective

To evaluate the factors that affect smallholder farmers in the counties of Machakos, Makueni, and Kitui's access to information about climate change adaptation and their willingness to pay for it.

### 1.3.2. Specific Objectives

i. To assess the perceptions and characteristics of the dissemination channels and climate change adaptation information accessed by smallholder farmers
ii. To assess the factors that influence smallholder farmers' access to information on climate change adaptation
iii. To evaluate the factors that influence farmers' willingness to pay for access to climate change adaptation information

### 1.3.3. Research Questions

i. What are the characteristics of the dissemination channels as perceived by smallholder farmers in the study area?
ii. What factors affect smallholder farmers' access to knowledge on climate change adaptation in the research area?
iii. What factors influence farmers' amount of willingness to pay for climate change adaptation information in the study area?

## 1.4. Justification

There are several reasons why a study on access to climate change adaptation information and willingness to pay is important and justified. The following reasons informed the need to carry out this study:

Global issues like climate change have an impact on all populations and locations. It is crucial to comprehend how various populations acquire information about adaptation to climate change and how ready they are to invest in adaptation strategies.

To help communities decide how to adapt to and lessen the effects of climate change, information about climate change adaptation is crucial.

The availability and accessibility of information can have a considerable impact on a community's ability to adapt to changing conditions.

The level of investment in adaption measures is significantly influenced by one's willingness to pay. Making decisions on the distribution of resources for adaptation can be influenced by an understanding of how communities value adaptation measures and how much they are ready to pay for them.

The study can offer significant insights for policymakers and practitioners on how to develop and implement successful adaptation programs by examining the relationship between access to knowledge about climate change adaptation and willingness to pay.

The study's conclusions can help ongoing research in this area and add to the body of knowledge on the economic implications of climate change adaptation.

The ability to comprehend how communities are adjusting to the effects of climate change and how they could be more successfully helped in their adaptation efforts depends on study on the availability of information on climate change adaptation and willingness to pay. The study's conclusions can help ongoing research in this area and add to the body of knowledge on the economic implications of climate change adaptation.

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### 1.5. Scope/Limitation of the study

Kitui, Machakos, and Makueni counties were the primary research area, as a result, the information reflects insights particular to the region. Also, the study concentrated on the factors that influence farmers' ability to access information about adapting to climate change and their readiness to pay to access this information.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1. Adaptation and Climate Change Definition

Globally, climate change has a significant negative impact on the growth of a sustainable economy. Its impacts affect both industrialized and developing nations. Climate change is defined as "long-term fluctuations in weather patterns, as indicated by changes in the mean and/or variability of its features," according to the IPCC (2012) and UNFCCC (2011). These changes might be brought about by human action or can occur naturally. Climate change is defined by variations in temperature, sea level rise, frequency of floods, and drought, among other impacts. It is also characterized by variations in rainfall, both in quantity and distribution.

According to Chen et al. (2016) and FAO (2019), the climate change effects on agricultural sector are mostly attributable to reliance on rain-fed agriculture, on which more than 19% of the global population is solely dependent.

The World Bank (2019), Kibue et al. (2016), and the International Monetary Fund (IMF) (2020) all assert that infrastructure, tourism, health, and other agro-based industries in Sub-Saharan Africa are being negatively impacted by climate change in addition to the agricultural sector. For instance, E. Muema et al. (2018) and Ruth et al. (2017) note that "agro-based sectors depend on agricultural outputs which are significantly influenced by droughts and floods, and the transport business is harmed by regular floods which hamper the movement of persons and commodities."

Erratic rainfall, increase in temperatures, and frequent droughts are the major climate vagaries that affect the agricultural sector in Kenya. The ASALs make up the largest landmass in Kenya (80%) and are the most prone to these impacts (Maina et al., 2013; Ochieng et al., 2020; Ojwang et al., 2010). Due to their reliance on weather-sensitive activities like herding and agriculture that relies on rain, nearly half of the population is considered to be below the poverty line. The frequency of drought events in the area has resulted in increased crop and livestock herds failures which aggravate food insecurity and increase the poverty level (Kwena et al., 2018; Mutunga et al., 2018).

The production of cereals and legumes on farmer's fields rarely exceeds 1t ha-1 and 0.5t ha-1, respectively, per season, according to studies by D'Alessandro et al. (2015) and Dhungel et al. (2016). Therefore, action must be taken to stop this threat in light of the current circumstance.

According to Lumosi et al. (2016, 2018), several approaches have been suggested to help address this difficulty. The use of crop and animal insurance, reducing the impact of climate change-causing elements, and adapting to it through accessing agricultural advisories that help with proactive planning of agricultural and farm investments are among the few. Crop and livestock insurance; to cushion farmers against the risks associated with climate change, insurance firms have come up with policies that allow farmers to insure their farms and livestock against this risk (Falco *et al.,* 2014). In these policies, farmers are expected to purchase certified and insured seeds and pay premiums for their livestock for compensation in the event of losses.

This venture especially in Kenya has proven difficult to sustain due to the underdevelopment of the sector as well as limited products onboarded, the lack of agricultural insurance infrastructure, a lack of farmers' knowledge and understanding of the risks associated with the cover and a lack of insurance culture among the farmers (Justus, 2017; Warner and Alemu, 2018; Chidiebere-Mark, 2019). The venture on the other hand has proven to be financially infeasible among the smallholder farmers.

Increasing "sinks" that prevent the accumulation of greenhouse gases in the atmosphere or lowering their source and production are the two main methods of mitigation that aim to reduce the flow of greenhouse gases into the atmosphere (IPCC, 2014). To produce the practical effects that farmers currently require, these climate change mitigation efforts will inevitably take a long time. Farmers now have the chance to adjust to the changing environment while reducing the causes of climate change as a result.

The IPCC defines climate change as "Adjustments in natural and human systems in response to actual or expected climatic stimuli or their impacts, which limit harm or exploit favorable possibilities."

Burton (1992) defined adaptation to climate change as the process through which people maximize the opportunities provided by their environment while minimizing the detrimental effects of climate change on their health and well-being.

Smit (1993) defined adaptation to climate change as adaptations made to socioeconomic activities to make them more resilient to the impacts of climate change, such as its current unpredictable nature, extreme occurrences, and longer-term climatic variability. Although these definitions of climate change adaptation range slightly from one another, they all point to the same actions that must be taken in order to adjust to the new environmental conditions brought about by climate change.

Adaptation can be classified in many ways; autonomous and planned adaptation (Fao, 2007) this is a classification based on intent or purposefulness. The response of a farmer to ecological changes in the natural system is referred to as autonomous, also known as spontaneous adaptation. Contrarily, planned adaptation is defined by Ruth et al. (2019) as "measures are deliberate policy alternatives or response strategies, frequently multi-sectoral in character, aiming at modifying the agricultural system's adaptive capacity or enabling specific adaption." This can be achieved through deliberate crop selection and distribution strategies across different agroclimatic zones, the substitution of old crops with new ones, and resource substitution induced by scarcity (Easterling, 1996).

Timing-based classification; Anticipatory versus Reactive adaptation; Anticipatory adaptation occurs before the occurrence of climate change effects. Farmers plan for the forthcoming season before hand in order to cushion themselves from climatic vagaries. Additionally known as proactive adaptation. Adaptation that is reactive to the effects of climate change (Ruth et al., 2019).

Agent-based classification: private vs public adaptation. An individual, household, or private institution may initiate and carry out private adaptation. Primarily motivated by the actor’s self-interest or by logic. While government at all levels initiates and implements public adaptation, this is primarily focused on the common requirements of a society or community.

Classification based on temporal scope: Short – run adaptation vs long – run adaptation; these forms of adaptation is dependent on the decision makers limitations by capital sock. Long – run adaptation allows a decision maker to make adjustment to their capital stock in response to climate changes.

The most relevant for this study was adaptation that focused on measures that are proactive, planned, public and run in the longest time possible to enable smallholder farmers reap on the opportunities presented by climate change.

Climate change adaptation includes a cocktail of actions that are aimed at decreasing vulnerability, growing resilience, moderating the hazards of climate effects on lives and livelihoods, and making the best out of the opportunities presented by changes in climatic events as indicated by (Otitoju

& Enete, 2016). It entails anticipating the vagaries of climate change, taking decisive action to prevent or lessen the harm they can cause, and seizing any opportunities that may arise. In the face of changing environmental, social and economic circumstances, adaptation helps farmers achieve their food, income, and livelihood protection goals. Therefore, by tactically responding to the changes at the farm level, farmers can minimize future crop loss.

Lumosi et al. (2016) stated that “besides the challenge of resource availability, adaptive capacity largely depends on the extent to which problems are understood, knowledge is accessible to vulnerable groups and policymakers, and adaptive responses are recognized and available to farmers.” Therefore, climate change adaptation information is the most important tool to help in this endeavor.

## 2.2. Climate Change Adaptation Information

The information has to be in a format that is consistent with the target area to respond to climate change. This is because studies indicate that climate change is location-specific, and its impacts differ across regions (Mutunga et al., 2018; Otitoju & Enete, 2016). Climate information on its own is not useful for decision-making. This information needs to be in a format that is compatible with farmers’ needs, timely and location-specific, understandable and user-friendly, easy to use, and more importantly accessible to vulnerable communities. Studies by Kirui, Waiganjo, and Cheplogoi (2014), Lumosi et al. (2016), Gebru et al. (2018), McGahey and Lumosi (2018), and Muema et al. (2018) are a few examples.

Various studies have endeavored to define climate change adaptation information. Muema et al (2018) define information for adaptation as Climate information that is accompanied by agronomic advice. World Meteorological Organization (WMO) defines climate services as the provision of information that is user-driven for risk alleviation and effective for application on-farm activities.

Donatti et al. (2017) concluded that information on adaptation to climate change should be location-specific, assist water management, and its danger to agriculture even when policymakers have limited access to scientific or technological expertise. This was done to make public the data that decision-makers need to gather in order to develop a smallholder farmer adaptation strategy to climate change.

The United Nations Food and Agriculture Organization (FAO), which outlines the requirements for a bundle of material to be recognized as information on climate change adaptation, served as the model for this study. Seasonal forecasting, suitable seed and crop varieties, water harvesting, soil fertility management, suitable agronomic methods, management of pests and diseases, post-harvest management strategies, and market information were discussed by FAO (2007) and Mujule et al. (2015) as the main groups for climate change adaptation information. The availability of this informational concoction is hence seen as the availability of information regarding climate change adaptation.

### 2.3. Information Sources and Communication Channels

There exists a contrast between information sources and information dissemination pathways or channels as used in the diffusion of information. An Information Source is an entity that provokes the exposure of a decision-making unit to information about an innovation (Jowi, 2018; Rogers, 2003), whereas a communication channel or pathway is the means through which information is transmitted from the source to recipients (Mai, 2016; Rogers, 2003). Rogers (2003) categorizes communication channels as disseminative (lacks feedback) or communicative (interactive) which allows feedback from both recipients and disseminators; Mass-media communication channels or interpersonal, cosmopolite which includes sources from outside the social system or locality communication channels. This study describes communication channels as communication/dissemination pathways.

The mandate of the provision of meteorological information in Kenya on a daily, monthly, and seasonal basis belongs to Kenya Meteorological Department (KMD). According to a report by (World Bank, 2016), 21 percent of climate information is disseminated by government agencies, 27 percent by the private sector, 21 percent by Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs), Research institutes, and academia at 17 percent and 14 percent by international organizations. Smallholder farmers mostly depend on their indigenous seasonal forecast that’s derived from natural indicators (Mutunga et al., 2018). This indigenous knowledge is a body of knowledge built on observation of natural occurrences that indicate changes in weather and seasonal status. This information is mostly used for decision-making in agricultural adventures, soil and water management, medicine as well as food production and preservation (Muema et al. 2018). These also added to sources of knowledge on climate change adaptation that educate farmers about adaptation. Lumosi et al. (2016) and McGahey & Lumosi (2018) discovered that private sources of knowledge have been credited with supplying more accurate information that tells farmers about climate change adaptation. Since the climate forecast has developed considerably reliable across all outlets, with technical growth.

In an attempt to help farmers to respond to climate change, diverse communication channels have been used to disseminate climate knowledge and services. Among them are:

### 2.3.1. Use of FM Radio

A study by Mwaniki et al. (2017) revealed that FM Radios can complement other agricultural extension services and can motivate them to act and engage in climate issues. The study also reveals that the listenership to climate change programs over the radio is limited since the programs might be aired at a time one is not listening. This, therefore, implies that farmers might miss out on important information although being disseminated. The limited intractability of most radio sessions is mentioned as limiting factor for provision of agricultural advisory and climate change information among farmers (Tumbo et al., 2018).

### 2.3.2. Use of Mobile phone technologies

With the exponential increase in technology development in Sub-Saharan Africa and especially in Kenya (Mas & Radcliffe, 2012; Nyasimi et al., 2017; Tumbo et al., 2018), use of mobile phone technologies have been used in disseminating information through calls, Short Message Services (SMS) and other mobile applications such as WhatsApp (Resende et al., 2019). Action on climate change has not been left behind, as information on adaptation has been communicated via these channels (Tricarico & Darabian, 2016; Gannon et al., 2018; Gebru et al., 2018). This mode of information dissemination has the limitation of cost constraints as most smallholder have low financial freedom to invest in these technologies.

### 2.3.3. Use of Internet technologies

There exist various web and mobile-based applications that provide agricultural advisory information in bulk. But most of the information is complex for stakeholders to make informed farm decisions after data analysis (Tumbo et al., 2018). Therefore, the use of these channels of communication for access to climate information for productive farm decisions is challenged.

Some non-ICT-Based communication channels used for disseminating climate change adaptation information have been Magazines and newspapers, Brochures and pamphlets, face–to–face communication, agricultural extension officer as well as CFS.

Climate Field Schools, referred as CFS, is a creative extension method that uses climate knowledge and agricultural forecasts to assist farmers in mitigating the threats associated with climate action to minimize insecurity and poverty. They are class sessions that offer in-depth preparation and learning of skills to help farmers promote their livelihood resilience. Participants are introduced to every step of the supply chain of climate and weather knowledge, from reliable rainfall estimation to the implementation of various prediction items, all to increase crop yields.

### 2.4. Information about climate change adaptation and smallholder farmers' perceptions

Understanding farmers' perceptions of climate change and information necessary for adaptation would help us better understand their level of understanding of these issues (Balasha et al., 2023). The study aids in identifying barriers and constraints to farmers' resource access and capacity for climate change adaptation. It also helps in detecting the already existing local expertise and the farmers' adaptive methods.

In eastern Ethiopia, Teshome et al. (2021) looked at smallholder farmers' perceptions of climate change and adaptation strategies for maize yield to show how crop production has been impacted by climate change. Farmers thought that a number of factors, including increasing temperatures and reduced rainfall, were the primary reasons for the region's decreased maize output. According to the study's findings, the main impacts of climate change on productivity include diminishing soil fertility, disease and pests, and drought. Despite attempts to show how smallholder farmers experience the effects of climate change, this study does not show how farmers perceive their capacity to gather data that helps adaptation measures.

Farmers' views are very strongly tied to past climatic trends, according to Ceci et al(2021) .'s investigation of smallholder farmers' perceptions of climate change and factors driving adaptation. His is essential in figuring out how they will adapt. The study's goal was to determine how past climatic changes have affected farmers' capacity for adaptability as well as their desire for knowledge and awareness of it.

## 2.5. Willingness to Pay

Willingness to pay mostly abbreviated as WTP is the maximum amount in monetary or in kind that one would be willing to part with to possess or enjoy a product or service offered. For the estimation of the economic value that an individual hypothetically assigns to a non-market value, such as the WTP to access climate change adaptation information, the Contingent Valuation Method (CVM) is majorly used (Breffle, Morey and Lodder, 1998; Ntanos *et al.*, 2018).

### 2.5.1. Review of Stated preference methods of CVM

Contingent Valuation Method is used to give value to a commodity that is typically incapable of receiving a market price, such as environmental resources like environmental protection, climate change mitigation, and/or adaptation among other non-market goods and services (Carson, 2000; Carson et al., 2001). An individual's view, attitude, and preferences about information on climate change adaptation and its non-market worth are extracted using the CV survey. Without any actual transactions taking place, a fictitious market is established (Kafy et al., 2018; Lee & Heo, 2016). The CV survey asked farmers to report their willingness to pay as they endeavor to have continued access to agro-advisory information on climate change and adaptation.

Jin et al. (2019) conducted a comprehensive assessment of research that evaluated WTP for climate change adaptation measures in developing countries, in contrast to other ways of assessing WTP to get climate change adaptation information. The Contingent Valuation Method (CVM) and Choice Experiments were discovered to be the most widely employed techniques, however there was significant variance in how these techniques were used and the outcomes that were attained.

Jiao et al. (2020) compared the CVM, Choice Experiments, and Open-Ended Contingent Valuation methods for estimating WTP for climate change adaptation information in China. They found that the Open-Ended CVM method was the most reliable and valid, as it allowed respondents to provide their own value estimates rather than being limited by a pre-determined set of response option.

Dikgang et al. (2015) compared the CVM and Choice Experiments methods for estimating WTP for climate change adaptation measures in South Africa. They found that both methods produced reliable estimates, although CVM method was easier to administer and had a higher response rate.

In contrast to methods that focus on respondents' disclosed preferences, this method emphasizes the respondents' expressed preferences (Chatterjee et al., 2017). The CVM technique can yield useful data regarding the demand for knowledge on climate change adaptation, including how much people are ready to pay for it and what influences their WTP (Zhang et al., 2020). CVM offers a broad range of applied and methodological case studies including a plethora of various public resources and natural resources (Loomis, 1990).

Different CVM designs are utilized to estimate WTP (Alvarez-Farizo, 1999); Loomis (1990) noted that the most popular designs are open-ended (OE) and dichotomous choice (DC). Loomis (1990) advocated OE designs nonetheless, adding that OE designs perform better than DC ones due to temporal stability.

## 2.6. Review of empirical studies on factors influencing access to climate change information

The factors influencing smallholder farmers in Kenya's access to climate change knowledge resources have been examined in several research. Muema et al. (2018) studied the factors that affect how people access and use climate information resources in Makueni County, Kenya. The research revealed that because older farmers have developed indigenous climate technique as a factor, age has a negative impact on access to knowledge about climate change. The study also showed that the likelihood of using climate information services was increased by having access to a variety of media channels, including radio, television, formal education, and prior exposure to the effects of climate change. However, the focus of this analysis was on the availability and use of resources for climate information, including seasonal climate information, forecasts for extreme events, local climate information, and day-to-day climate information.

Mutunga et al. (2018) investigated adaptability of smallholder farmers to climate change in Kenya's Kitui County. In the report, information about person's age, farming experience, household size, education level, access to finance options, access to climatic data, and access to weather forecasts was outlined. The village of origin also has an impact on how successfully farmers in Kitui county are adjusting to the changing climate.

In contrast to earlier studies, this study endeavored to determine whether other factors outside socioeconomic ones affected farmers' access to knowledge about climate change adaptation.

## 2.7. Examining empirical research on the factors affecting smallholder farmers' willingness to pay for information on climate change adaptation

Farmers' attitude toward and readiness to pay to access climate information in Burkina Faso were evaluated by Zongo et al. (2015). Farmers are eager to make financial contributions to receive the benefits of climate information in order to lower climate risk and increase productivity, according to the report. Unlike the study by Zongo et al, (2015) that focused on climate information; especially on maize and sorghum production, this study sought to evaluate the farmer's willingness to pay and the factors influencing their decision for climate change adaptation information. The study also focused on the whole agricultural venture, not in specific sectors. The study determined the information and farmers' characteristics that influenced their willingness to pay.

A study by Ouédraogo et al. (2018) on farmers' willingness to pay for climate change information services in northern Burkina Faso showed that several socioeconomic and motivational factors influenced smallholder farmers' WTP. Among these factors, age, gender, education and literacy levels of farm heads and their awareness about climate change adaptation and its impact influences their WTP. In contrast with this study which focused on cow peas and sesame value chain as well as weather forecast information. This study focused on agricultural ventures regardless of the value chain.

## 2.8. Theoretical Framework

### 2.8.1. The concept of Communication and Communication Channels

The study defines communication as the process through which information is disseminated from source to recipient through a communication medium with the desire/intent to change the receiver's attitude, knowledge and practices. This relates to the Laswell (1948) conceptual model that described the communication process by answering the questions; Who (source/sender) says what (Message), through what medium (Communication Channel), to whom (Recipient/receiver) and with what effect (impact to receiver's behavior/feedback).

#### 2.8.1.1. Laswell's theory of Communication

Laswell's communication model has five components which is used as an analysis tool for evaluating the communication process and components. The model was developed to analyze mass communications, interpersonal or group communication to disseminate messages to various groups of recipients in various situations.

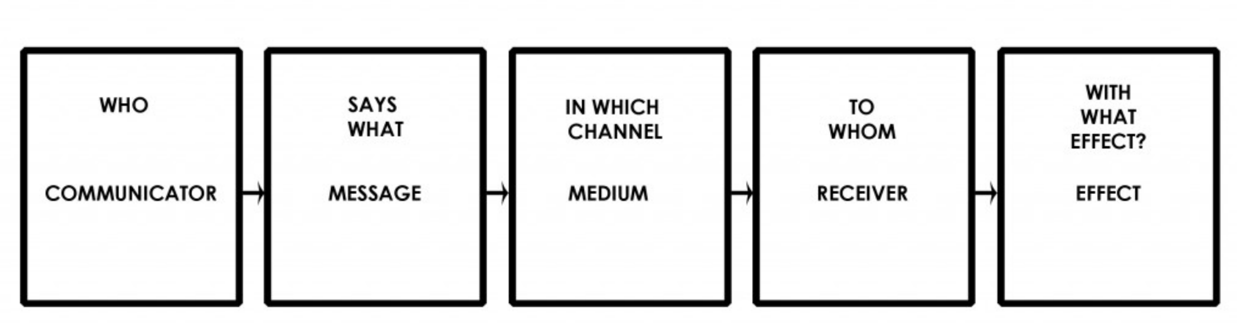



*Figure 1: Laswell's illustration of flow of communication from source to recipient*

It also borrows from Rogers (2003) diffusion of innovation by outlining the concept of "Through what medium" (communication channel). Rogers defines a communication channel as the means through which a message (information) traverses from the sender to the receiver. The major channels of communication of climate change adaptation information in the study area was characterized as mass media communication channels comprising of Radio, Televisions and Print media, and interpersonal communication channels comprising of Farmer groups, Agricultural extension officers.

Hypothetically, mass media channels create awareness to members of a social system about the existence of an innovation. The interpersonal channels on the other hand motivate the individuals to accept (adopt) or reject the innovation. The study was also very cognizant that the diffusion process of climate change adaptation information starts from knowledge (awareness) and is coherent with persuasion, through which the farmer forms a favorable attitude or otherwise about the innovation which lead to the decision making of usage and finally confirming their adoption of use of the climate change adaptation information.

#### 2.8.1.2. The Theory of Planned Behavior (TPB)

A social psychological theory known as the Theory of Planned Behavior (TPB) describes how an individual's attitude, subjective norms, and perceived behavioral control affect behavior. Is was used to determine what factors led a person to look for and use information about climate change adaptation (Shah Alam and Mohamed Sayuti, 2011).

An individual's assessment of the activity and its results is referred to as their attitude. An individual's attitude towards the significance of the information and their perceptions of its possible advantages can have an impact on their behavior towards knowledge about climate change adaptation.

The term "subjective norm" describes the perceived social pressure to liv according to the standards of many significant groups, including friends and family. The opinions of others and the perceive significance of the knowledge to others around them can affect a person's decision to seek out the information gravitating towards climate change adaptation.

An individual's apparent capacity o engage in a behavior is referred to as perceived behavioral control. Information about climate change adaptation may be seen as being accessible and usable by person differently depending on their geographic location, educational background, and access to resources.

By considering these factors, the TPB provided insight into the factors that influence an individual's decision to seek out and use climate change adaptation information, and can inform efforts to improve access to this information. For example, if an individual perceives the information to be important, feels social pressure to access it, and has the resources and access to do so, they are more likely to engage in the behavior of seeking out and using the information. On the other hand, if an individual does not believe the information is important or does not have access to the resources to access it, they may not seek it out. Therefore, the TPB provides a useful framework for understanding the factors that influence an individual's decision to seek out and use climate change adaptation information, and can inform efforts to improve access to this information.

### 2.8.2. The concept of willingness to pay

Willingness to Pay (WTP) is a concept that quantifies the highest price a person will pay for a specific commodity or service. WTP is used in demand theory to calculate the demand curve, which depicts the relationship between the cost of a good or service and the volume of units that customers are willing to buy at that cost.

The application of WTP in the context of climate change adaptation requires an understanding of people's willingness to pay for access to knowledge, resources, and technology that can help them adapt to their environment. For example, a study of WTP for access to information on climate change adaptation might involve surveying individuals to determine their willingness to pay for access to online resources, workshops, or educational materials. The results of the survey could then be used to estimate the demand for these types of resources, and inform the development of targeted interventions to improve access.

Overall, the application of WTP in the context of climate change adaptation can provide important insights into the preferences and needs of individuals and communities, and guide the creation of focused and efficient actions to provide access to resources and information about climate change adaptation.

# CHAPTER THREE

# METHODOLOGY

## 3.1. Conceptual Framework

To reduce climate change vulnerabilities, adaptation to climate change necessitates behavioral changes in individuals, groups, and institutions. These institutions include the county-level ministries of agriculture, water, natural resources, commerce, community development, and communications as well as national organizations that produce and disseminate information about the climate, such as the KMD and KALRO, among other research institutions. Figure 2 illustrates the predicted major determinants of adaptability as being economic capital, technology, knowledge and experience, infrastructure, organizations, and equity (Smit 2001). Access to economic services is improved by increased availability, but lack thereof diminishes the likelihood of adaption.

The availability of technological outputs like drought- and heat-tolerant plants as well as sophisticated infrastructure broaden the range of potential adaption possibilities. Greater informational accessibility increases the likelihood of timely and adequate adaptation, but a shortage of skilled professionals and farmers restricts the ability to adopt the essential adaptation measures. The provision of utilities, such as water harvesting dams for home and agricultural water supply, roadways, and communication networks, will strengthen the adaptive capability.

By increasing access to information that is pertinent to the local area and supporting households by giving them the resources they need to act on the information they receive, well-developed and functional institutions at the local and national levels contribute to reducing the effects of climate-related risks and enhancing adaptive capacity. The impacted population's ability to adapt is limited by the unequal distribution of information, money, technology, and infrastructure resources, whereas the equitable distribution of these resources fosters adaptation (Smit, 2001).

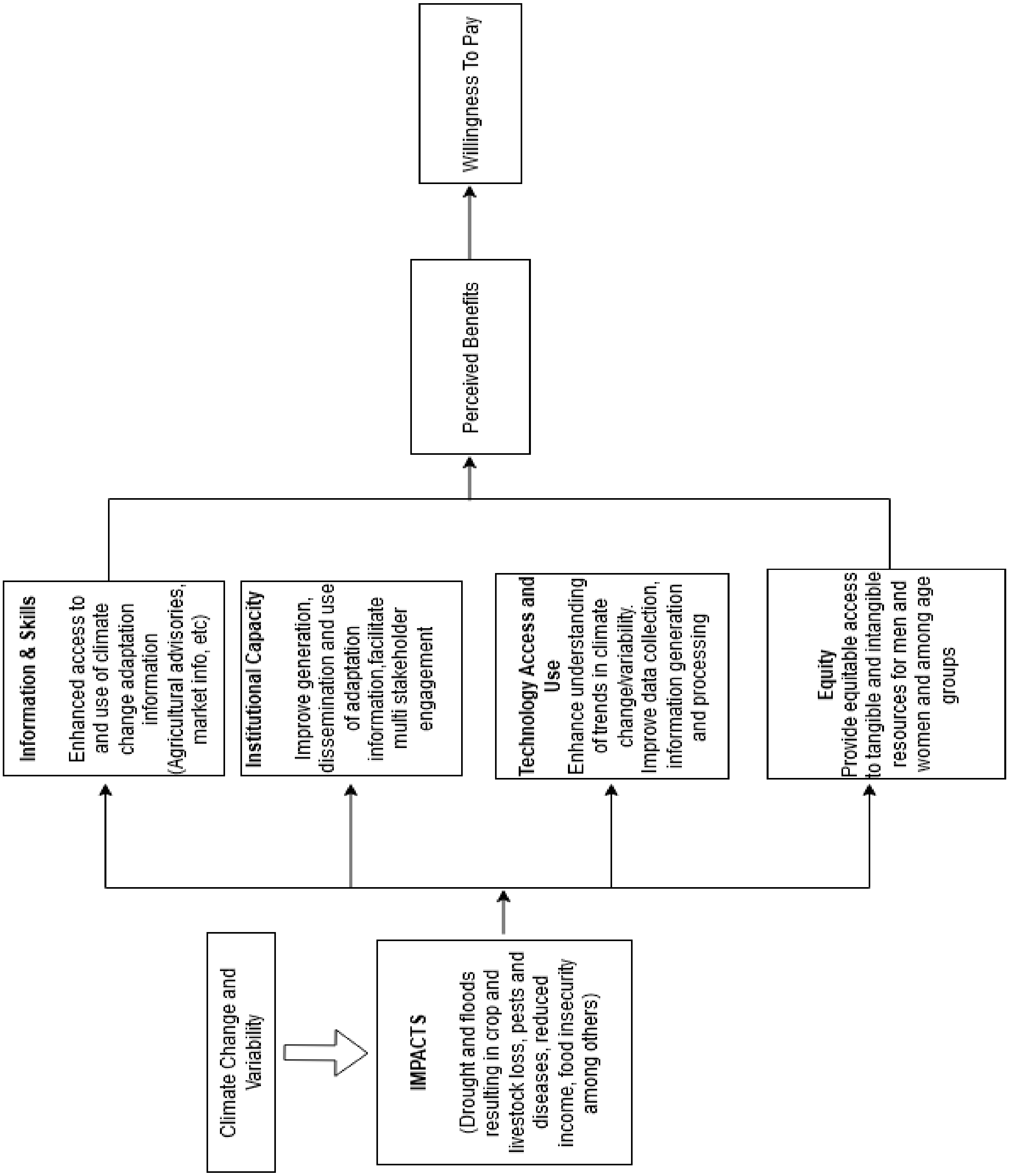



*Figure 2: Conceptual framework for climate change adaptation information and farmers' willingness to pay*

### 3.2. Study Area

Three semi-arid counties, Kitui, Machakos, and Makueni, were the locations of the study (Figure 3). The impact of climate change in these regions have resulted to very erratic and insufficient rainfall patterns posing a considerable danger to crop and livestock output (Gichangi et al., 2015; Muema et al., 2018; Othieno, 2014; Yohannis et al., 2019).

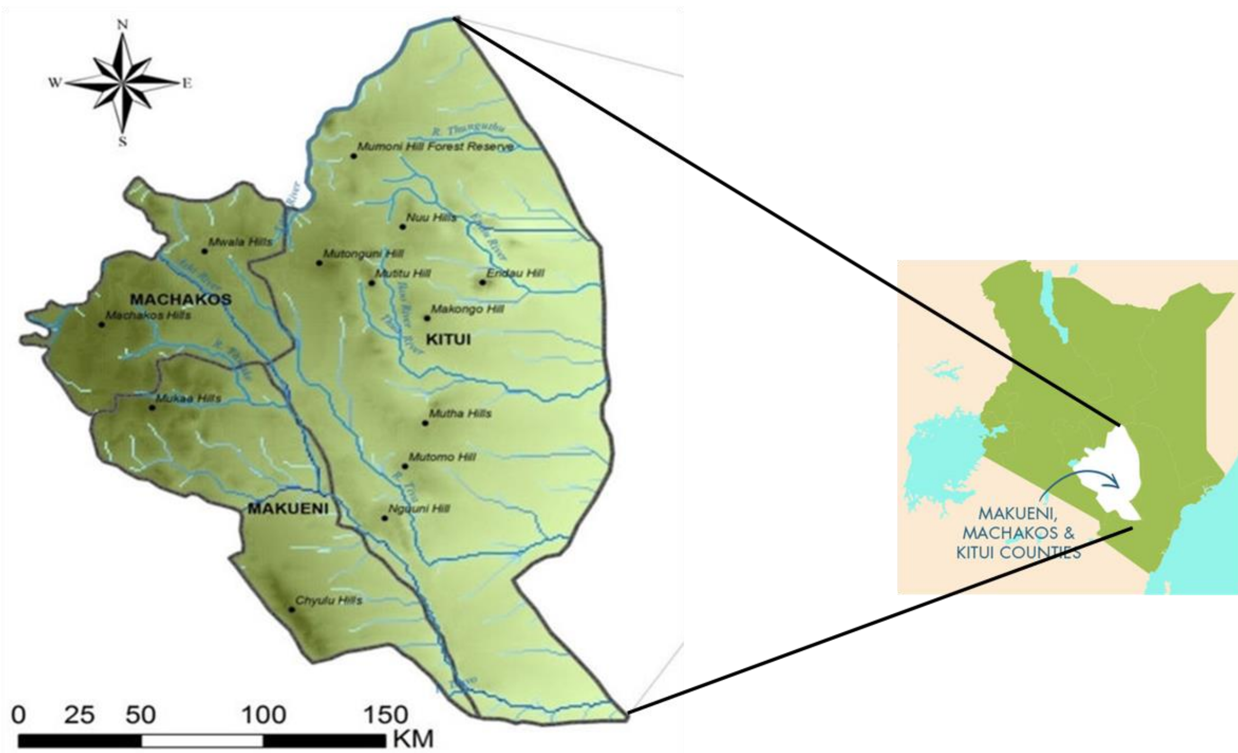



*Figure 3: Map of the stud area (Kitui, Machakos and Makueni counties)*

#### 3.2.1.Machakos County

Machakos County sits on 6,208 $Km^2$ of land mass with a population estimated at about 1,414,022 (KNBS, 2019) based on the projections from the 2019 census. The county is categorized into five agro-ecological zones (AEZs) based on the potential crop production suitability (Jaetzold et al., 2010; KNBS, 2015): UM 2-3: mostly suitable for maize, beans, dairy, and coffee. The Upper Midland zone 5 to 6(UM 5-6) is suitable for ranching. The lower midland (LM3) is suitable for mangoes, maize, pigeon pea, cowpeas, and indigenous poultry. The lower midland4 (LM4) is suitable for maize, beans, mangoes, cowpeas, indigenous chicken, and pigeon peas production. Dairy, beans, maize, pigeon peas, cowpeas, mangoes, and indigenous poultry are all appropriate for the Lower Midland5 (LM5).

The majority of Machakos is semi-arid and desert (ASAL), with an annual rainfall range of 500 to 1300 mm (MoALF, 2017; Muriithi et al., 2021). The range of temperatures is 18 to 29 °C, with October and March being the warmest months and July being the coolest.

Agribusiness is adversely affected by erratic and poor rainfall as well as high temperatures, leading to widespread, persistent food insecurity and increased poverty among people who are primarily dependent on natural resources (GoK, 2013). According to climate models, there is a chance that rainfall will become more irregular, that seasons will start and end at different times, and that temperatures will continue to rise, increasing the risk of drought, drought and flash floods in some regions (Huho and Mugalavai, 2010).

Crop and animal productivity are already declining, soils are deteriorating, there are more pests and diseases affecting both crops and livestock, fewer water resources are available, and some long-known perennial rivers are drying up or becoming seasonal (GoK, 2012). . Therefore, in order to effectively adapt to expected changes, farmers must have access to climate change adaptation information.

### 3.2.2. Makueni County

Makueni county is located in the southeastern part of Keya. It covers approximately 8,034.7 km2, most of which is arid and semi-arid (MoALF, 2016). The low-lying landscape of Makueni District is unique, with the exception of the hilly areas of Kilungu, Mbooni and Chyulu Hills, the population is about 977,015 out of 244,669 households from the 2019 Kenya Census of Population, Houses and Dwellings (KNBS, 2019 estimate).

The county receives two rainy seasons per year, long rains in March, April and May and short rains in October, November and December. The rains are unevenly distributed, with about 800-1200 mm of precipitation falling in the hilly parts of the region, and about 300 mm falling below normal in the lower areas. Temperatures range between 20.2 and 35.80 degrees Celsius (GoK, 2013).

The county is categorized into several Agro-Ecological Zones (AEZs), namely: Lower Highlands (LH), Upper Midland (UM) and Lower Midland (LM).

The agricultural sector is an integral part of Makueni County's economy. It employs approximately 78% of the population and contributes a similar percentage to household income. Major agricultural value chain commodities for income generation, food security and production include local poultry, green gram, mango and dairy cows. Climate change and variability remain a major challenge for the agricultural sector in Makueni.

The district's most dangerous climate risks include drought, heat stress, increased precipitation, moisture stress and higher temperatures. These threats are likely to become more frequent, according to an analysis of recent climate events and predictions for the region's upcoming climate. The trend shows that drought is more likely to occur in LH4, LH5 and LM6 AEZs which include Makindu, Kalawa and Mtitu Andei. Increased rainfall is likely to occur in wetter areas such as Kilungu and Mbooni which fall under AEZ LH2.

#### 3.2.3. Kitui County

Kitui covers approximately 30, 570 $km^2$ with an estimated population of 1,130,134 from 262,942 households. The County receives between 500- 1050mm of rainfall annually. The topography of the landscape influences the amount of rainfall received. The highland areas receive 500-1050mm per year while the drier lowlands receive less than 500mm. The short rains are more reliable and are the county's principal productive season. The long rains usually provide about 30 percent of crop production enabling the production of pulses like green grams and pigeon peas. The County has several agro-ecological zones transition of UM3 -4, UM4, LM4, 5, 6, and lowland 5 and 6 (L5, 6) (Jaetzold *et al*., 2010**)**. Since the 1960s both minimum (night) and maximum (day) temperatures have been on a warming trend throughout Kenya, the current projections indicate temperature increase (NEMA, 2013). Trends of increased inter-annual variability and distribution of rains, with an increased number of successive dry days and shorter, high rainfall intensity periods have been noted.

## 3.3. Sample Size and Sampling Techniques

### 3.3.1. Sample Size determination

The target population for analysis in the focal counties consisted of smallholder households that depended on agriculture as a means of livelihood. Using the Kothari (2004) formula, the sample size was calculated as follows:

$n = \frac{(z^2 pq)}{e^2}$ ……………………………………… (eq i)

Where z is the normal variate equal to 1.96, p is the approximate proportion of the calculated attribute, which if the proportion is unknown, is 50 percent, q = (1-p), and e is the desired accuracy, which is assumed to be 5 percent.

the Hence: $n = \frac{(1.96^2 \times 0.5 \times 0.5)}{0.05^2} => 384.16 \ \approx 385 \, respondents$

Due to the unpredicted occurrence of protest bids and the possibility of unanswered questionnaires, the sample size was adjusted by 15 percent to 443 households to accommodate the challenge. The adjustment in the sample size was to help reduce the margin of error and to allow for data cleaning.

### 3.3.2. Sampling Technique

The study adopted a multi-stage sampling technique to reach the desired sample size. In the first phase, Kitui, Machakos and Makueni counties were purposively selected. The counties were selected based on their geographical location in arid and semi-arid regions which are more vulnerable to climatic instability and transition ambiguity with other regions (GoK, 2013, 2016; Birch, 2018). Additionally, Canada's International Development Research Center (IDRC) funded the Kenya Agriculture and Livestock Research Organization (KALRO) to work with a regional project on "The Last Mile: Up-Scaling Climate Information Services to Build Community Resilience in Uganda and Kenya" in an effort to provide down-scaled information on climate change adaptation.

In the second sampling stage, two sub-counties were randomly selected from each county. In the third stage, two wards were randomly selected from each sub-county, and finally, 443 respondents were randomly selected from all villages proportionally.

## 3.4. Data collection and analysis

### 3.4.1. Data Collection

A data collection tool (Semi-Structured questionnaire) was deployed for the household survey. The questionnaire was uploaded on Open Data Kit (ODK) programmed and downloaded on tablets/smartphones from which it was administered. The questionnaire covered a variety of topics, including the socioeconomic characteristics of the households, the types and sources of information farmers used to adapt to climate change, the ways in which those farmers perceived those resources, their needs for information, and their willingness to pay for it. A copy of this instrument is annexed to this report.

A database was generated to storage of the research responses in Kobo Toolbox. Primary data was collected using a semi-structured questionnaire developed through the Kobo toolbox application. Prior to distribution, the questionnaire underwent pretesting and any necessary modifications in order to collect data on information sources, access methods, and factors affecting farmers' access to the data related to climate change adaptation. Descriptive statistics were used to analyze and present qualitative and categorical data using the statistical package for social science (SPSS) application version 26.

To find out whether smallholder farmers in the counties of Kitui, Makueni, and Machakos were prepared to pay for knowledge on climate change adaptation, a poll was performed among them.

Demographic, adaptation to climate change knowledge, and willingness to pay questions were all included in the poll.

A five-point Likert scale was used to record farmers' responses in order to evaluate how smallholder farmers perceived information about climate change adaptation and the channels employed for its dissemination.

The Likert scale was created to measure how well-liked the target channels and information were by smallholder farmers in terms of their impressions of their many characteristics.

The following were the agreed-upon levels:

One - Strongly Disagree, two represents Disagree, Three - Neutral, Four - Agree, and Finally, Strongly Agree.

Information on farmers willingness to pay was a binary outcome on whether they are willing to pay or otherwise. The amount the farmers were willing to pay and the mode of payment was also captured. The mode of payment comprised of payment in Cash (through Monetary contribution) or in kind by donation of yield from the seasons produce.

### 3.4.2. Data Analysis

Data collected from the field was managed at Kobo toolbox server. Cleaning was performed to ensure correctness and complete questionnaires were ready for analysis. The Data was shipped for analysis to the Statistical Package for Social Science (SPSS) application version 26.

#### *3.4.2.1. Characterizing the climate change adaptation information and communication channels accessed bey smallholder farmers*

To determine the type of climate change adaptation information and resources that may be accessed through the different channels of distribution, a Principal Component Analysis (PCA) was carried out. PCA is a methodology that helps reduce the dimensionality of a large number of interrelated variables of a dataset while preserving as much of the variation in the dataset as possible (López del Val and Alonso Pérez de Agreda, 1993). The information received by farmers through the various dissemination channels were subjected to PCA that resulted to various Principal Components (PC) which represented a reduced variable enough for analysis.

Kaiser-Meyer-Olkin (KMO) test for sampling adequacy was applied on each variable in the dataset to provide the overall index for the entire set of variables. KMO evaluates the proportion of variance among the variables that might be caused by underlying factors. Its statistic ranges from 0 to 1, with values closer to 1 indicating better suitability for factor analysis. The KMO values above 0.6 are usually considered acceptable, while values above 0.8 are considered good.

Bartlett's test of sphericity which evaluates whether a correlation matrix is an identity matrix. The test determines whether the observed correlation matrix is significantly different from the identity matrix. If the p-value of Bartlett's test is less than the chosen significance level (eg, 0.05), it indicates that there is significant evidence to reject the null hypothesis of any underlying factors, indicating that the data are suitable for factor analysis.

The results from the Likert scale was analyzed through determining the mean preference of the various characteristics that defined perceptions and valued between 0 (Zero) and 5 (Five). Farmers' average perceptions were used to calculate the effectiveness of climate change dissemination channels. The factors the help determine effectiveness characteristics of channels are as enlisted in the effectiveness equation below. Effectiveness (*y)* was calculated as:

$$Effectiveness(y) = timeliness\ (x1) + accuracy(x2) + reliability\ (x3) + comprehensablity\ (x4) + user\ friendliness\ (x5) + credibility(x6) + informativeness(x7) + availability(x8).$$

### *3.4.2.2. Factors that influence smallholder farmers access to climate change adaptation information*

A Probit regression analysis was applied to determine factors that influenced the smallholder farmers' access to climate change adaptation information. Using this approach, access was considered as a binary outcome with 1 representing access and 0 otherwise. The model predicted the probability of a value falling into one of two possible binary results (Hausman and Wise, 1978).

$pi = Prob\ (yi = 1|xi) = \varphi(z)$ ………………………………………………………….. (eq. ii)

Equation (eq ii) modeled the likelihood of y=1 using the cumulative normal distribution function, $\varphi(z)$, evaluated at $z = \beta 0 + \beta 1x1 + \cdots + \beta kxk$, hence the Probit model represented by equation (iii) below.

$\Pr(y = 1|xi) = \varphi(\beta 0 + \beta 1x1 + \cdots + \beta kxk)$ ……………………………………………….(eq. iii)

Where $\varphi$ was the cumulative normal distribution function and $z = \beta 0 + \beta 1x1 + \cdots + \beta kxk$ was the "z-value" of the model.

Access to climate change adaptation information was the dependent variable whilst age, gender, education level, household size, farm size, the main source of income, farming experience, understanding of climate change adaptation, group membership, access to radio, television, mobile phones, and internet, friends and workshops were the independent variables. The Akaike Information Criteria (AIC) (Claeskens and Jansen, 2015) was used to select the model that provided the best fit to the dependent variable.

Akaike Information Criteria (AIC) is a model selection tools that strikes balance between the goodness of fit and model complexity (Akaike, 1974). The AIC value is used to compare different models fitted to the same dataset. The model with the lowest AIC value is considered the best-fitting model among the candidates. A lower AIC indicates a better balance between model fit and complexity.

### 3.4.2.3. *Factors influencing smallholder farmers WTP or climate change adaptation information*

The Ordinary List Squares (OLS) model was used to analyzed the factors that influenced the amount the farmers were willing to pay to access climate change adaptation information. The OLS model can be represented by the following formula:

$$WTP = \beta_0 + \beta_1X_1 + \beta_2X_2 + ... + \beta_pX_p + \varepsilon$$

From this formula: WTP represents the dependent variable, i.e., the willingness to pay for climate change adaptation information. $\beta_0$ is the intercept term, representing the constant or baseline value of WTP when all explanatory variables are zero. $X_1, X_2, ..., X_p$ represent the p explanatory variables (also known as independent variables or predictors). $\beta_1, \beta_2, ..., \beta_p$ are the respective regression coefficients that quantify the impact of each explanatory variable on WTP. $\varepsilon$ represents the error term, accounting for the unexplained variation in WTP not captured by the explanatory variables.

The following independent variables were hypothesized to impact the smallholder farmers WTP:
Farm characteristics: Variables such as farm size, farm type (e.g., crop farming, livestock farming), and years of farming experience.
Socio-economic variables: Variables related to farmers' socio-economic status, such as income, education level, and access to credit or financial resources.

Perceptions and attitudes: Factors influencing how farmers feel about climate change, including perceived dangers, awareness of its effects, and the efficacy of adaptation strategies.

Information sources: Availability of agricultural extension services, participation in farmer networks, or exposure to climate change training programs are examples of factors related to th source of information about climate change that farmers can access.

External factors: Variables related to external factors that may influence WTP, such as government policies or support programs, the availability of adaptation technologies or infrastructure, and the presence of market incentives.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1. Socio-economic characteristics of the sampled households

The socioeconomic characteristics of households in the three counties are summarized in Table 1 below. The results showed that 74.9% of the households were predominantly male. The average age of the household head was 52.92 years with 22.22 years of farming experience. This shows that most of the small farmers in the study area are older and have been active in the agricultural industry for a considerable period of time. As reported by Heide-Ottosen and Vorbohle (2014), the number of elderly farmers in rural areas in developing countries is increasing faster than in developed regions and reaching absolute levels. Compared to urban areas, rural areas are disproportionately home to older people. From the report, evidence of aging in agriculture shows that in sub-Saharan Africa, more than one-third of agricultural holders are over 55 years of age.

These findings support Muema et al. (2018), Murithi et al. (2021), Mutunga et al. (2018), and Onyango et al. (2021) who found that the average age of farmers with more than 15 years of farming experience was 53 years.

The average household size was 5.42 persons and household heads were mainly married persons which was consistent with Murithi et al. (2021) and Kenya National 2019 Census findings. These findings showed that the household size in these regions was between three to six members and averaged 5 persons per household (KNBS, 2019). The extended family provides the labor force involved in agricultural production. Family farming plays a key role in agriculture and food production, particularly in SSA. As indicated by Moyo (2016), about 85 percent of investment in terms of financial savings and labor value applied to agriculture in SSA is accounted for by family farms.

The results showed that most of the families depended on agriculture as the main source of livelihood. The study reveals that 51.9 percent of households are dependent on agriculture as a source of livelihood both through labor and income. This large family provided convenient labor force which was deployed in climate change adaptation activities like water harvesting, land preparation. This is evident from a study by Mutunga, Ndungu and Muendo (2018); Murithi et al. (2021).

*Table 1:Socio-Economic characteristics of households*

| Variable | Unit | Kitui | Machakos | Makueni | Whole sample ($\boldsymbol{n = 443}$) |
|---|---|---|---|---|---|
| Male-headed households | Percentage | 73.1 | 71.4 | 80.9 | 74.9 |
| Farm size | Acres | 4.99 | 2.04 | 3.99 | 3.99 |
| Household Size | Number | 5.61 | 4.96 | 5.68 | 5.42 |
| Marital Status | Percentage | | | | |
| Married | | 75.6 | 81.0 | 82.4 | 79.5 |
| Single | | 4.4 | 4.1 | 3.7 | 4.1 |
| Widowed | | 18.8 | 15.0 | 11.8 | 15.3 |
| Divorced | | 1.3 | 0.0 | 2.2 | 1.1 |
| Age of Household Head | Years | 51.81 | 54.68 | 52.31 | 52.92 |
| Farming experience | Years | 21.58 | 24.29 | 20.70 | 22.22 |
| Education Level | Percentage | | | | |
| None | | 6.9 | 4.8 | 4.4 | 5.40 |
| Primary | | 53.8 | 42.2 | 53.7 | 49.90 |
| Adult education | | 0.0 | 0.0 | 0.7 | 0.20 |
| Secondary | | 25.6 | 37.4 | 29.4 | 30.7 |
| College/University | | 13.8 | 15.6 | 11.8 | 13.8 |
| Main Income | Percentage | | | | |
| Salaried Employment | | 9.4 | 21.8 | 12.5 | 14.40 |
| Farming | | 48.8 | 47.6 | 60.3 | 51.9 |
| Business | | 14.4 | 10.9 | 4.4 | 10.2 |
| Casual Labor | | 25.6 | 19.7 | 22.8 | 22.8 |
| Children Support | | 1.3 | 0.0 | 0.5 | 0.50 |
| Remittances | | 0.6 | 0.0 | 0.2 | 0.20 |
| Source of Labor | Percentage | | | | |
| Family | | 56.9 | 53.1 | 57.4 | 55.8 |
| Hired | | 3.8 | 12.9 | 4.4 | 7.0 |
| Family & Hire | | 39.4 | 34.0 | 38.2 | 37.2 |
| Land Ownership | Percentage | | | | |
| With Title deed | | 34.4 | 34.0 | 28.7 | 32.5 |
| Without Title Deed | | 35.6 | 27.9 | 39.7 | 34.3 |
| Leased | | 0.6 | 0.0 | 3.7 | 1.4 |
| Inherited | | 29.4 | 38.1 | 27.9 | 31.8 |
| Group Members | Percentage | | | | |
| Farmer Association | | 72 | 63 | 58 | 65.0 |
| Credit Association | | 90 | 40 | 57 | 66.0 |
| Climate Field School | | 18 | 36 | 27 | 26.0 |
| Self Help Groups | | 89 | 41 | 56 | 65.0 |
| Business Cooperatives | | 05 | 00 | 03 | 3.0 |

The average farm size of households was 3.99 acres owned by inheritance at 31.8%, with title deeds and at 32.5% and 34.3% without title deeds. This result is similar to Kenya's Ministry of

Agriculture, Livestock and Fisheries (MoALF, 2016). Secure land tenure is critical when addressing challenges and implementing climate change adaptation strategies. The IPCC report confirms that land tenure is a key parameter in any discussion of land-climate interactions. Farmers who own their land are important in protecting existing forest and soil cover to help reduce land degradation through erosion (Kukkonen and Pott, 2019).

Majority of household heads have at least primary school education (49.90%) while 44.5% have post-primary education. This confirms the findings of the World Bank (2020) that the literacy level in Kenya was 82%, with a lower percentage that transitions to the post-primary level. Farmers with low levels of literacy may have limited access to information distributed through non-vernacular channels and print media such as farmer magazines, pamphlets, etc. United Nations Climate Action research has found that education can motivate people to change behavior and attitudes and help them make informed decisions. In the case study, farmers with higher levels of education are better equipped to make decisions related to climate change adaptation.

Farmers in the three counties participated effectively in farmer associations (65%), credit and loan associations or table-banking (66%), and self-help groups (65%). From the findings by Ogunli et al. (2021), farmers' participation in initiatives to access social capital, such as farmer groups, among other organizations, increases their chances of accessing and adapting to climate change. Farmers share more insights on farming opportunities, adaptation information sources and implementation.

## 4.2. Characterization of climate change adaptation and channels accessed by smallholder farmers

All the farmers perceived that the weather (climate) has changed in the past 5 – 10 years. This is evident from numerous studies carried out in the region to ascertain climate change awareness (GoK, 2018; Kitinya, 2012; Muema et al., 2018; Muriithi et al., 2021; Onyango et al., 2021). A significant increase in precipitation was reported by 51.4% of the total sampled population. A majority (86.7%) of the sample population observed an increase in atmospheric temperatures. This finding corroborates with findings IPCC, World Meteorological Organization (WMO), and National Climate change Actions (NCCA) which have predicted an increase in temperature and amount of precipitation in the East African region (Government of Kenya, 2018; IPCC, 2019; World Meteorological Organization, 2021b).

Forty-one-point eight percent of the farmers observed that their area had become more productive in the past three years (2018, 2019 & 2020) compared to the preceding 5 to 10 years (Table 2). These results support the World Bank's assessment that climate change has decreased crop productivity in the region (World Bank, 2021). This drastic reduction in crop yields could be attributed to crop failures caused by prolonged droughts, flooding, pest, and diseases as well as soil degradation.

*Table 2:Farmer perceptions of climate change and land productivity*

| Variable | Unit | Kitui | Machakos | Makueni | Total ($\boldsymbol{n = 443}$) |
|---|---|---|---|---|---|
| Climate change understanding | Percent | 87.5 | 95.9 | 95.6 | 93.0 |
| Climate change adaptation understanding | Percent | 77.5 | 75.5 | 77.9 | 77.0 |
| Area Productivity | Percent | | | | |
| More Productive | | 23.1 | 41.5 | 64.0 | 41.8 |
| Less Productive | | 63.1 | 49.7 | 33.8 | 49.7 |
| Same/No Change | | 13.1 | 8.8 | 2.2 | 8.4 |
| Rainfall Perception | Percent | | | | |
| Increased | | 34.4 | 52.4 | 70.6 | 51.4 |
| Reduced | | 59.4 | 42.8 | 25 | 43.3 |
| No Change/Same | | 6.3 | 4.8 | 4.4 | 5.2 |
| Temp Perception | Percent | | | | |
| Increased | | 85 | 86.3 | 89 | 86.7 |
| Reduced | | 4.4 | 4.1 | 6.6 | 4.9 |
| No Change/Same | | 10.0 | 8.8 | 4.4 | 7.9 |

Source: Author (2021)

Like in the case of  Muema et al. (2018); Muriithi et al. (2021); Onyango et al. (2021), farmers in the three counties adopted water harvesting (82%), crop diversification (82%), changed their crop variety (66%) and adopted crop rotation (59%) as climate change adaptation methods. These results are as show in figure 4 below. Farmers have adopted climate change adaptation methods at a high rate, which can be attributed to the active dissemination of agro-advisories and information about such measures (Kwena et al., 2018).

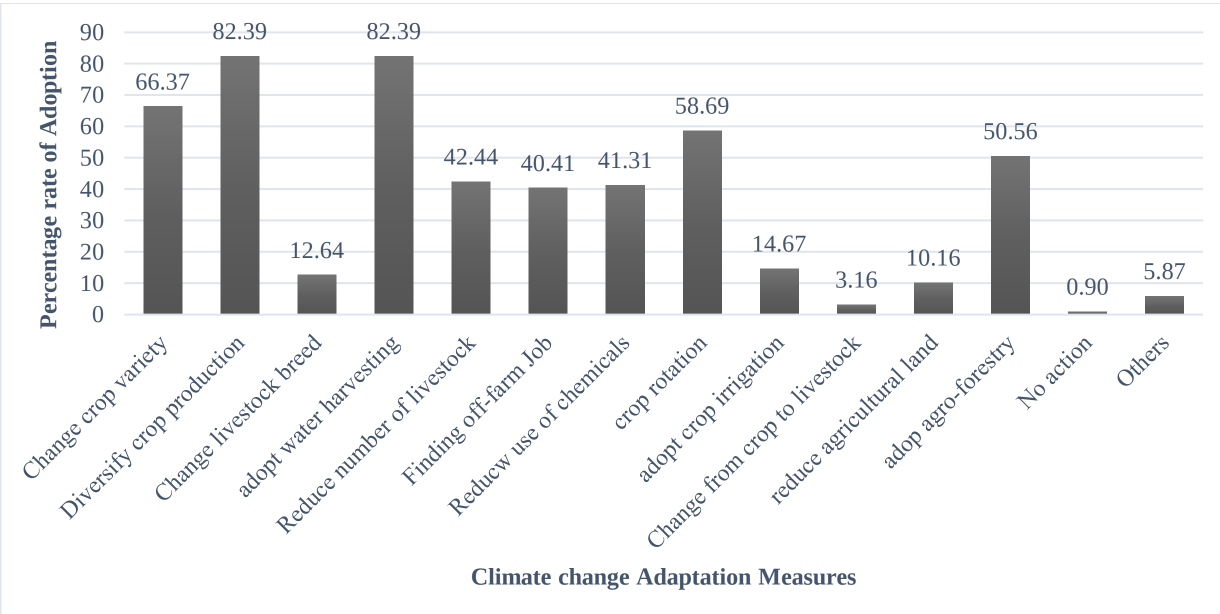



*Figure 4: Climate change adaptation measures adopted by farmers*

### 4.2.1. Climate change dissemination channels and their characteristics

Table 3 summarizes the main communication channels used by smallholder farmers in Kitui, Machakos and Makueni Counties to access climate change adaptation information. From the results, it is apparent that most farmers accessed climate change adaptation information through radio (86%) followed by farmer groups (50%) and agricultural extensionists (46%) in the second and third positions, respectively.

*Table 3:Communication channels used by farmers, their preference and reasons for preference*

| Channel | Uses (%) | Prefers (%) | Reasons for preference | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Affordable (%) | Accessible/ Owned (%) | Authentic (%) | User friendly (%) | Referenceable (%) | Informative (%) | Interactive (%) | Reliable (%) |
| Radio | 86.0 | 64.6 | 9.2 | 58.8 | 5.6 | 5.2 | 0.8 | 66.8 | 6.0 | 28.4 |
| Television | 18.7 | 37.3 | 2.9 | 58.8 | 8.8 | 8.8 | 5.9 | 82.4 | 38.2 | 41.2 |
| Mobile Phone | 11.5 | 37.3 | 25.7 | 77.1 | 17.1 | 25.7 | 57.1 | 22.9 | 17.1 | 25.7 |
| WhatsApp | 1.13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Internet/ Web | 3.39 | 46.7 | 22.2 | 33.3 | 44.4 | 22.2 | 55.6 | 55.6 | 0.0 | 22.2 |
| Farmer Magazine | 13.3 | 39.0 | 33.3 | 7.4 | 77.8 | 33.3 | 74.1 | 85.2 | 29.6 | 48.1 |
| Workshops | 15.4 | 44.1 | 4.5 | 11.4 | 18.2 | 9.1 | 18.2 | 90.9 | 90.9 | 65.9 |
| Friends | 23.7 | 20.0 | 4.8 | 9.5 | 4.8 | 9.5 | 38.1 | 33.3 | 71.4 | 23.8 |
| Group | 50.3 | 47.5 | 15.9 | 30.2 | 36.5 | 53.2 | 73.8 | 97.6 | 96.0 | 82.5 |
| Extension Officers | 45.8 | 73.4 | 10.7 | 12.7 | 72.6 | 28.4 | 37.6 | 85.8 | 89.8 | 76.6 |
| Pamphlets | 10.2 | 28.9 | 23.1 | 23.1 | 15.4 | 38.5 | 92.3 | 100 | 0.00 | 53.8 |
| Barazas/ Opinion Leaders | 6.09 | 14.3 | 100 | 57.1 | 14.3 | 28.6 | 42.9 | 57.1 | 57.1 | 42.9 |

Source: Author (2021)

Majority of the farmers who used radio to access climate change adaptation information preferred it because they owned radios (59%), and considered radio to be more comprehensive and adequate in its coverage (67%). These results corroborate findings by Elia (2017), Mwaniki et al. (2017) and Popoola et al. (2020) that majority of smallholder farmers access their climate change-related information from radios because it is the most available channel to them. Most farmers (48%) who accessed climate change adaptation information through groups preferred this channel mainly because demonstrations were carried out hence information accessed was easy to use and understand (user-friendly) (53%), could refer if not in attendance (74%), was informative (98%), interactive (96%) and considered groups as a reliable source of information for CCA (83%). Similarly, majority of the farmers (73%) who accessed information through agricultural extension providers considered them authentic (73%), informative (86%), interactive (90%), and reliable

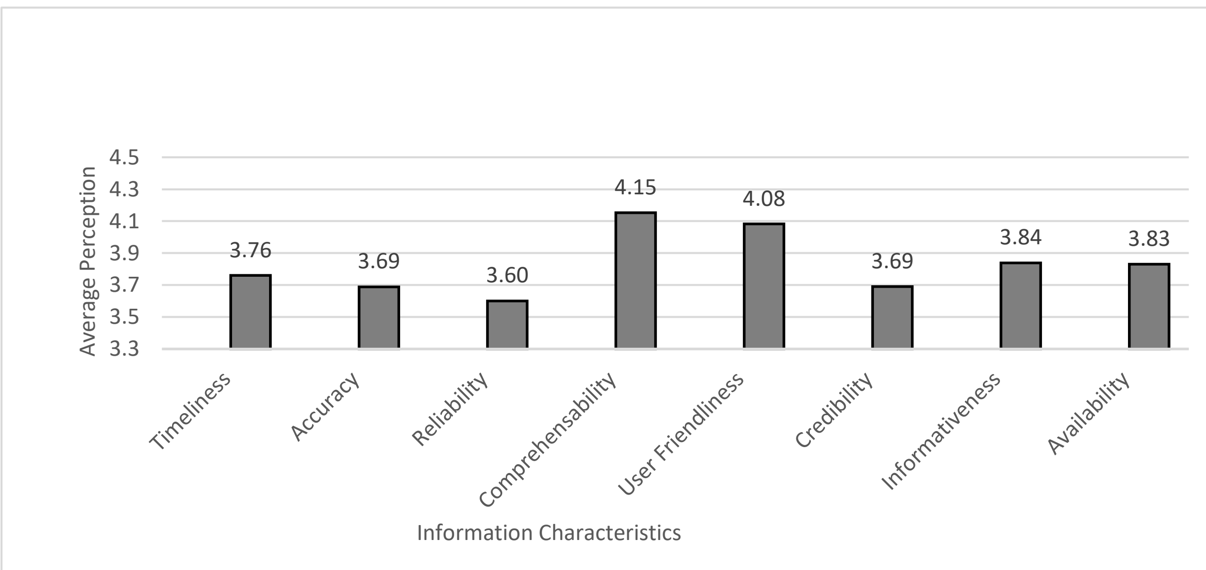
(77%). These results support findings by UNFCCC that farmer groups usually share their climate change adaptation experiences with other villagers thereby enhancing information transmission among farmers (Nwabueze Chukwuji *et al.*, 2019).

### 4.2.2. Smallholder farmers' perceptions of the effectiveness of climate change adaptation information accessed through different dissemination media

Most of the farmers emphasized that they received information on climate change adaptation through various means of distribution.

According to Figure 5, which shows a Likert scale with 1 indicating "strongly disagree," 2 indicating "agree," 3 indicating "neutral," 4 indicating "agree," and 5 indicating "strongly agree," Farmers' views were examined.

*Figure 5: Farmer perceptions on characteristics of accessed climate change adaptation information*




On a scale of 1 – 5, the farmers were able to comprehend the information disseminated more at an average of 4.15 likelihood. Farmers agreed that the information was timely enough at an average of 3.76. The information was user-friendly (easy to implement) at an average of 4.08. the results also show that the farmers agreed that the CHAI was informative enough at 3.84, this indicated that the information accessed covered most of the climate change adaptation measures hence adequately addressed the challenge of climate change. The information was cited to be accurate, reliable, credible, and easily accessible(available) at an average of 3.69,3.60,3.69 and 3.83 respectively.

### 4.2.3. Patterns of information accessed through various dissemination channels

A number of communication channels that smallholders used to obtain information were characterized using principal component analysis (PCA). The Kaiser-Meyer-Olkin (KMO) measure should be greater than 0.70 and is considered inadequate if less than 0.50. Bartlett test is significant with significance value less than 0.05; this means that the variables are sufficiently correlated to provide a reasonable basis for factor analysis. The rotating correlation coefficients associated with the extracted principal component (PC) are explained based on the magnitude of factor loading coefficients (≥± 0.40). Factors whose loadings are below |0.40| were excluded from the output. A positive coefficient indicates a positive association and vice versa. For each component, the variables with the largest pattern coefficients contribute the most to explaining the total variance in the data.

#### 4.2.3.1. Climate change adaptation information accessed through Radio

The PCA Model fitting results for characteristics of climate change adaptation information accessed through radio is a show in table 4. The goodness of fit for the model is as explained by Bartlett's test of sphericity (Chi-square ($\chi^2$) =1349.510, df=45, p=0.000; KMO=0.845). A KMO value greater than 0.5 indicates adequacy to perform PC analysis.

*Table 4: Factor patterns with rotated correlation coefficients for radio*

| Climate change adaptation information variables | Factor Loadings | |
|---|---|---|
| | PC1 | PC2 |
| Livestock Production | 0.757 | |
| Environment Conservation | 0.751 | |
| Livelihood Adjustment | 0.700 | |
| Post-Harvest Management | 0.624 | |
| Crop and Variety Adjustment | | 0.761 |
| Warnings and Forecast | | 0.748 |
| Market Information | | 0.576 |
| Soil and Water conservation | | 0.558 |
| Pest and Disease Management | | 0.507 |
| Agronomic Practices | | 0.503 |

| *Total variance Explained (52.89)* | *28.03* | *24.86* |
|---|---|---|

The PCA model fitting results led to the extraction of two components which explained 52.89% of the total variance. Of the two components, the first principal component (PC1) explained about 28.03% of the total variance. From PC1, Radio played a great role in disseminating information to farmers on livestock production. Similarly, Crop and variety Adjustments loaded favorably on component two (PC2). PC2 accounted for 24.86% of total variance. This indicated that the smallholder farmers majorly received information on Livestock Production and Crop and Variety Adjustments from radios. Since majority of the farmers accessed and used radios as their primary source of information on climate change adaptation. Information based on the two adaptation measures can therefore be accessed by farmers easily and reliably through radio.

#### 4.2.3.2. Climate change adaptation information accessed through Television

The results for the PCA model fitted to characterize information received through television are shown in Table 5. Goodness of fit was derived from the results as shown by Bartlett's test of sphericity as ($\chi^2$=1840.965, df=55, p=0.000; KMO=0.822) KMO value was greater than 0.5, this was sufficient to conduct PCA.

*Table 5: Factor patterns with rotated correlation coefficients for televisions*

| Climate change adaptation information variables | Factor Loadings | | |
|---|---|---|---|
| | PC1 | PC2 | PC3 |
| Agronomic Practices | 0.854 | | |
| Soil and Water Conservation | 0.752 | | |
| Crop and seed Varieties adjustment | 0.608 | | |
| Livelihood Adjustment | 0.604 | | |
| Livestock Production | | 0.808 | |
| Warnings and Forecast | | 0.695 | |
| Post – Harvest Management | | 0.602 | 0.583 |
| Environment Conservation | | | 0.795 |
| Market Information | | | 0.647 |
| Pest and Diseases Management | 0.465 | | 0.489 |
| *Variance explained (65.86)* | *25.13* | *22.41* | *18.32* |

Three components were extracted from the model that explained 65.86% of the total variance. PC1 accounted for 25.13% of the total variance, thus capturing the most significant relationship among information on climate change disseminated through television. Agronomic practices which includes basic farm preparations and management loaded favorably under this principal component. Under the second principal component which accounted for 22.41% of the total variance, information on livestock production loaded favorably. From the third PC, environment conservation information had a significant loading. This in conclusion indicated that the characteristics of information accessed via television is mainly on agronomic practices, livestock production and on environment conservation. Munene and Mberia (2016) in their study on effects of television shows on small-scale farmers information in Kenya confirmed that televisions have been proven to be effective in disseminating information on important technologies and innovations for improving farming methods and productivity.

#### 4.2.3.3. Climate change adaptation information accessed through Mobile phones

Three components were extracted from the PCA analysis of information accessed through Mobile phones accounting for 67.36% of the total variance as in Table 6. The model showed the goodness of fit for the data fitted (KMO = 0.705, Chi-Square = 2018.998, df = 45, and p = 0.000 for the Bartletts Test of Sphericity. Information obtained through mobile phones includes information obtained through interactive voice response (IVR) and short messaging services (SMS) (IVR).

*Table 6: Factor patterns with rotated correlation coefficients for mobile phones*

| Climate change adaptation information | Factor Loadings | | |
|---|---|---|---|
| variables | PC1 | PC2 | PC3 |
| Pest and Disease Management | 0.783 | | |
| Soil and Water Conservation | 0.759 | | |
| Livelihood Adjustment | 0.744 | | |
| Livestock Production | 0.713 | | |
| Post – Harvest Management | 0.696 | | |
| Agronomic practices | 0.677 | | |
| Environment Conservation | 0.619 | | |
| Warnings and Forecast | | 0.897 | |
| Crop and Varietal Adjustments | | 0.803 | |
| Market Information | | | 0.898 |
| *Variance explained (67.36)* | *37.01* | *17.47* | *12.88* |

Component one accounted for most of the variance explained at 37.01%. From this component (PC1) information pest and diseases management was the most dominant. Soil and water conservation and livelihood adjustment information loaded favorably under PC1 but with a lower factor loading coefficient. Warnings and forecasts information loaded favorably under PC2. This variable shows that information on Weather forecasts and warnings are reliably accessed by farmers through mobile phones as represented by its high factor loading coefficient under this PC.

From the third component, PC3, information on market availability and prices had a favorable factor loading. This shows that farmers were able to access information on market for their products through use of mobile phones easily.

With the improvement and diffusion of mobile phone technology in Kenya, access to information via mobile phone especially in SMS form is rampant. As put forward by Raithatha and Tricarico, (2019), the advancement of technology and usage of mobile phone has improved the access of information on climate change including daily forecast among other adaptation information.

Generally, it is clear that farmers were able to access climate change adaptation information focused on pest and disease management, weather forecast and market information favorably through mobile phones.

#### 4.2.3.4. Climate change adaptation information accessed through Farmer Magazines

The PCA results of CHAI that farmers accessed through farmer magazines are as represented in Table 7 below. A KMO value of 0.904, Bartlett's Sphericity Test with statistical significance of a p-value of 0.000, Chi-Square = 5287.484, and df = 36 were the results of the goodness of fit test.

*Table 7: Factor loadings for rotated correlation coefficients for Farmer magazines*

| Climate change adaptation information variables | Factor Loadings | |
|---|---|---|
| | PC1 | PC2 |
| Pest and Disease Management | 0.959 | |
| Soil and Water conservation | 0.957 | |
| Agronomic Practices | 0.949 | |
| Crop and Varietal Adjustments | 0.943 | |
| Post – Harvest Management | 0.941 | |
| Livelihood adjustment | 0.879 | |
| Environmental Conservation | 0.746 | |
| Warnings and Forecast | 0.695 | |
| Market Information | | 0.982 |
| *Total Variance Explained (83.28)* | *70.42* | *12.87* |

From the results, two components were extracted. The total variance explained by the results of PCA model on information accessed through Magazines was about 83.28%. The rotated correlation coefficients factor loadings that constituted the first principal component (PC1) explained about 70.42% of the total variation. All climate change adaptation information loaded favorably on component one, but information on pest and disease management was the dominant factor with the highest factor loading coefficient. Farmers were able access information mainly on pest and diseases as well as soil and water conservation whose coefficients were significantly close. From the second component, PC2, market information loaded favorably with 98.2% factor loading coefficient value. Farmers who had access to farmer magazines had the honor of accessing information on market prices and availability for their farm products.

#### 4.2.3.5. Climate change adaptation information accessed through Friends and Peers

Table 8 is a representation of the PCA model results fitting CHAI accessed through Friends and Peers. The Bartletts Test of Sphericity has an approximated Chi-Square of 1316.117, degree of freedom (df) of 45, and a p-value of 0.000 indicating significance at the 1%significance level. The KMO measure of Sampling adequacy is 0.733, indicating that the data was adequate to perform principal component analysis.

*Table 8: Rotated correlation coefficient factor patterns for Friends and Peers*

| Climate change adaptation information variables | Factor Loadings | | |
|---|---|---|---|
| | PC1 | PC2 | PC3 |
| Pest and Diseases management | 0.843 | | |
| Soil and Water Conservation | 0.792 | | |
| Post – Harvest Management | 0.677 | | |
| Agronomic Practices | 0.650 | | |
| Livelihood adjustments | | 0.746 | |
| Forecast and Warnings | | 0.741 | |
| Crop and seed Variety adjustments | | 0.692 | |
| Environment Conservation | | | 0.754 |
| Livestock Production | | | 0.729 |
| Market Information | | | 0.533 |
| *Variance explained (61.73)* | *25.07* | *19.57* | *17.08* |

Three Principal Components were extracted accounting for 61.73% of the total variance. Of the results, Principal Component 1 explained about 25.07% of the total variation. The factor that loaded favorably under this component was pest and disease management. It can be concluded that most of the farmers through their social network exchanged information on pest and disease control amongst each other. With a factor loading coefficient of 74.6%, livelihood adjustment variable loaded favorably under PC2, thus indicating that farmers shared amongst each other on modes and ways of improving their livelihoods through farming and climate change adaptation.

Information on environment conservation was also shared among farmers and their peers as illustrated by the factor loading of 75.4% on principal component three (PC3) as illustrated in the Table 8. Therefore, from the results above, farmers consistently shared information on Pest and Disease control, livelihood adjustments and environment conservation amongst each other.

#### 4.2.3.6. Climate change adaptation information accessed through Groups/Climate field Schools (CFS)

The results of the PCA model fitted for groups are presented in Table 9. The model had goodness of fit represented by KMO measure of Sampling adequacy of 0.904 and Bartletts test of Sphericity with Chi-Square = 3228.713, df = 45, and p-value = 0.000. indicating that the model was significant at a 1% significance level and was adequate to warrant PCA.

*Table 9: Factor loadings with rotated correlation coefficients for Groups*

| Climate change adaptation information variables | Factor Loadings | |
|---|---|---|
| | PC1 | PC2 |
| Crop and Varietal Adjustment | 0.886 | |
| Agronomic practices | 0.869 | |
| Soil and Water conservation | 0.817 | |
| Pest and Disease management | 0.781 | |
| Warnings and Forecast | 0.770 | |
| Livelihood adjustment | 0.757 | |
| Post – Harvest Management | 0.736 | |
| Livestock Production | 0.598 | 0.574 |
| Market Information | | 0.815 |
| Environmental Conservation | 0.556 | 0.564 |
| *Variance explained (70.43)* | *51.94* | *18.48* |

From the results in Table 9, two principal components were extracted which accounted for 70.43% of total variance explained by the fitted model. From the results of the model, PC1 explained 51.94% of total variance. Among the components loading under PC1, Crop and Seed variety adjustment was the key factor loaded. Indicating that farmers were able to share and access information on the required, appropriate or recommended crop and seed variety suitable for the season or climatic condition from group gatherings like CFS. As evident from the study by Benson, James and John (2015), farmers in farmer groups tend to share mostly knowledge on appropriate crop variety and adjustments.

The factor loading on PC2 which accounted for 18.48% of the total variance. Market information loaded favorable under PC2 indicating that among other information accessed by smallholder farmers from CFS and farmer groups, market availability and prices for their products was disseminated. As showcased by Ferris et al. (2014), in their study on linking smallholder farmers to markets, farmer groups come out as one of the critical areas where farmers gather and engage in discussions concerning product prices and market availability. Similarly, Miriti (2012) while evaluating factors influencing the effectiveness of farmer groups in cereals market demonstrated that due to long distance to market places, farmer groups act as centers for poor farmers to access information or sale their products.

#### 4.2.3.7. Climate change adaptation information accessed through agricultural extensionists

The Bartletts' Test of Sphericity indicated that the results of the model fitted for agricultural extension service providers as given in Table 10 had a satisfactory fit (Chi-Square = 3702.703, df = 45, p-value =0.000). The KMO score of sample adequacy was 0.939, indicating that PCA could be performed well.

*Table 10: Agricultural Extension service providers' patterns of rotated correlation coefficients*

| Climate change adaptation information variables | Factor Loadings | |
|---|---|---|
| | PC1 | PC2 |
| Crop and Seed variety adjustment | 0.909 | |
| Pest and Disease management | 0.896 | |
| Post – Harvest Management | 0.876 | |
| Soil Fertility and Water Conservation | 0.874 | |
| Agronomic practices | 0.862 | |
| Warnings and Forecast | 0.862 | |
| Livelihood Adjustment | 0.806 | |
| Livestock Production | 0.799 | |
| Environment Conservation | 0.714 | |
| Market Information | | 0.995 |

| | | |
|---|---|---|
| *Variance explained (74.95)* | *64.51* | *10.44* |

Two components were extracted from the model which accounted for 74.95% of the total variance. Of this variance, principal component one (PC1) explained 64.51% of the total variance. The factor/variable that loaded favorably under this component was information on crop and seed variety adjustment. This indicates that agricultural officers disseminated information to farmers that targeted majorly on diversity of crops and seeds to help in coping with climate changes.

The second principal component (PC2) explained about 10.44% of the total variance. Market information loaded favorably under PC2 indicating that, agricultural extension officers were keen while advising farmers on market availability and prices for their produce.

From the PCA results, the primary information received by farmers from various communication channels loaded with the highest factor loading coefficient for both PC1 and PC2. This is based on the characteristics of the dissemination channels that made it easier for the information to reach to the smallholder farmers effectively.

**4.3. Factors influencing smallholder farmers' access to information on CCA**

Table 11 shows the findings on the factors influencing smallholder farmers in the study area's access to information on climate change adaptation. According to the findings, access to knowledge about CCA among farmers was significantly explained by household heads gender at a 5% level of significance ($p = 0.032$), and access to CHAI was positively correlated with gender. This suggest that, compared to household headed by women, households headed by men typically received climate change adaptation information more frequently. This finding is similar to those found by Andrijevic *et al.* (2020); Glazebrook, Noll and Opoku (2020).

According to a study by Gebru et al. (2015, 2018), gender-bias inequalities brought on by unfair laws, socially constructed gender roles, and cultural norms not only render women vulnerable but also restrict their access to information about coping with climate change. Women are more involved in farming, especially in sub-Saharan Africa as pointed out by Oduol *et al.* (2017); Paul Otieno (2019); Wekesah, Mutua and Izugbara (2019); Crossland *et al.* (2021), hence should be receiving climate change adaptation information more than their male counterparts.

Education level was significant at a 5% significance level ($p = 0.037$) with a positive correlation when explaining access to CCA information. As a result, it was determined that educated people had a higher likelihood to have access to information on CCA. More years spent in school tend to raise awareness of the importance of knowledge for adaptation. Education is critical to understanding and using knowledge to address the impacts of climate change through behavioral and attitudinal change. Adopting more sustainable lifestyles and developing skills that support diverse economies, according to the United Nations Educational Scientific and Cultural Organization (UNESCO) Program (UNESCO, 2019) helps in this endeavor.

Group membership, significant at 1% significance level (p = 0.000) with a positive coefficient implied that subscription to groups especially farmer associations and climate field schools impacted favorably towards climate change adaptation information access. From the findings, it is evident that groups were more interactive and increased interpersonal communications among members which influences the exchange of information. As stated by (Rogers, 2003) interpersonal communication was key in enabling behavior change and adaptation of innovation through strengthening of social Networks among farmers thus leading to increased information flow (Othieno, 2014; Abid *et al.*, 2017; Dapilah, Nielsen and Friis, 2020).

Knowledge of climate change adaptation has a favorable influence on smallholder farmers' access to information on adaptation in South-Eastern Kenya. A p-value of 0.000 indicated that knowledge of climate change adaptation was significant at a 1% level of significance. Farmers are driven to seek out and obtain climate change adaptation information as they become more aware of its hazards and management measures.

The nature, quality, and strength of farmers' CCA depends on their level of awareness. This is reasoned by Abbasi & Nawaz (2020) and Khatibi et al. (2021) on "impact of climate change awareness on climate change adaptation". "Public action on climate change will not begin until the public understands climate change and their role in the fight against it." Akpan *et al*. (2012) reasoned, "particularly in the area of forcing the authorities to make and implement meaningful policies aimed at increasing climate change awareness and understanding amongst smallholder farmers is key."

The findings also indicated, at a 5% level of significance, that farmers' access to knowledge on climate change adaptation was positively impacted by having access to communication channels like radio, television, and mobile phones.

In his study, Nyang'anga (2015) notes that the lack of extension service providers in comparison to the number of farmers has resulted in a stretched-thin ratio of extension service providers to farmers. Similar to the research of Popoola, Yusuf, and Mond (2020), which claims that radio and television have a key role in the spread of information about CCA.

The media has a significant role in raising awareness and influencing how people see climate change. Similar to a study from Ghana, conducted by Ndamani & Watanabe (2015), radio and television were the main media used by smallholder farmers to obtain weather information. The majority of their respondents (85.3 percent) depended on the media (TV and radio) for knowledge about climate change, and Annor-Frempong & NanaAcquah (2012) found that it is one of the most effective sources. In their 2012 study on the effect of Nigerian mass media on public understanding of climate change, Akpan et al. discovered that respondents preferred television, the internet, and interpersonal communication above newspapers as their primary sources of information.

Table 11: Factors influencing farmers’ access to climate CHAI

| Dependent Variable: Access to CCA Information | | | |
|---|---|---|---|
| Independent Variables | Coefficient | Std. Err | P value |
| Age of Household Head | -0.017 | 0.0133 | 0.210 |
| Gender of Head (Male) | 0.379 | 0.1763 | 0.032 ** |
| Number of Persons in the Household | -0.007 | 0.0345 | 0.850 |
| Size of Farm | -0.004 | 0.0148 | 0.783 |
| Education Level of Head | 0.245 | 0.1174 | 0.037 ** |
| Main Income Source | -0.067 | 0.0978 | 0.495 |
| Group Membership | 0.673 | 0.1852 | 0.000 *** |
| Farming Experience | 0.007 | 0.0080 | 0.37 |
| Knowledge of Climate change Adaptation | 0.758 | 0.1707 | 0.000 *** |
| Radio as Channel | 0.508 | 0.2548 | 0.046 ** |
| Television as Channel | 0.667 | 0.2782 | 0.017 ** |
| Mobile as Channel | 0.698 | 0.3485 | 0.045 ** |
| Web/internet | -0.235 | 0.4506 | 0.602 |
| Workshops | 0.528 | 0.3630 | 0.146 |
| Friends/Peers | 1.014 | 0.2168 | 0.000 *** |
| Groups | 0.702 | 0.1949 | 0.000 *** |
| Agricultural extensionists | 1.471 | 0.2300 | 0.000 *** |
| Barazas | 0.035 | 0.3389 | 0.917 |
| Communication channel Effectiveness | 1.247 | 0.1729 | 0.000 *** |

Note: Number of observations: 443 households, Omnibus test: Likelihood Ratio $\chi^2$ = 78.964, significant at 1% level (p = 0.000). ***, ** and * represents 1%, 5% and 10% significance level respectively.

Social networks through friends, Groups, and Agricultural extension officers impact farmers' access to CHAI at a 1% level of significance (p = 0.000). From this study’s findings, these channels were characterized by being Authentic, informative, and interactive, the findings which corroborated with those from the studies by Antwi-Agyei & Stringer (2021). Maponya & Mpandeli (2013) while explaining the roles of agricultural extension service providers stated that the agent's role is characterized as being educational through provision and dissemination of information to farmers, providing institutional support, and helping them meet their needs. From the study by Othieno (2014) on analysis of social networks of climate change adaptation communication in Makueni county, the results showed that homophily in the social networks which formed through interpersonal communication between friends & peers and group interactions enhanced the horizontal flow of CHAI. This study contributed to those findings by showing that knowledge access on CCA among farmers was significantly influenced by friends, peers, and group interactions.

A statistically significant factor that affected smallholder farmers' access to knowledge on adaptation was the efficiency of the dissemination pathways used for distribution of that information. Effectiveness significantly influenced farmers' access to information at the 1% level. As stated by Susan et al. (2019), challenges of information dissemination such as language barriers, inaccuracy, lack of access to communication devices hamper access to CHAI among smallholder farmers.

### 4.4. Farmers' willingness to pay for access to CCA information

The results on farmers' willingness to pay for CHAI in southeastern Kenyan counties of Kitui, Machakos and Makueni is as illustrated in Table 12. From the results, majority of the smallholder farmers (77.2%) were willing to pay to access CHAI in South-Eastern Kenya. Out of these farmers, 62.05% were willing to pay in monetary form while 37.95% in kind, through the provision of farm produce (Livestock and farm crop produce). The average amount in cash farmers were willing to pay was Kenyan Shillings (Ksh.) 1445.56 per year. WTP in kind was distributed among different crop yields that the farmers were willing to offer as their mode of payment. Fifty-one-point six percent of the farmers were willing to pay through offering maize yield in facilitating the dissemination of CCA information. Farmers were willing to contribute an average of 66.97 kg of maize which translated to Ksh. 2013.56 per year based on the current market wholesale price of Ksh. 2,706 per 90 kg bag of maize according to (NCPB, 2021).

The farmers were asked about their reasons for WTP to access CCA information. Fifty-eight percent of farmers who were willing to pay indicated that the information was beneficial in supporting their farm investment decisions. The farmers' main objection to paying was that they considered the information to be a public utility that the government should supply without charge. This was constituted by 12.6% of the farmers. Similarly, Farmers claimed to be unable to pay for such information at 19.4%. This can be associated with the limited amount of income generated by farmers who depend mostly on farming as their only source of income.

*Table 12: Smallholder farmers willingness to pay (WTP)*

| **Variable** | **Unit** | **Total (n=443)** |
|---|---|---|
| Willingness to Pay (WTP) | Percent | **77.2** |
| **Mode of Payment** | Percent | |
| *Cash* | | **47.9** |
| *Kind* | | **29.3** |
| Payment in Cash | Kenyan shillings (Ksh) | **1,445.66** |
| **Payment in Kind** | Percentage | |
| Maize | | **51.6** |
| Beans | | **7.1** |
| Green grams | | **32.5** |
| Tomatoes | | **1.6** |
| Pigeon Peas | | **0.8** |
| Cowpeas | | **5.6** |
| Sorghum | | **0.8** |

| **Crop Yield** | **Percentage of WTP** | **Average (Kilograms)** |
|---|---|---|
| Maize | **51.6** | **66.97** |
| Beans | **7.1** | **58.89** |
| Green grams | **32.5** | **38.51** |
| Tomatoes | **1.6** | **70.00** |
| Pigeon Peas | **0.8** | **50.00** |
| Cowpeas | **5.6** | **39.14** |
| Sorghum | **0.8** | **50.00** |

Source: Author (2021)

**4.5. Factors influencing smallholder farmers' WTP to access CCA information**

According to the empirical findings, factors such as education level, age, primary source of income, comprehension and access to information on CCA, duration of access, availability of markets, and effectiveness of the information all had a statistically significant impact on farmers'

WTP. The findings of the factors affecting farmers' desire and ability to pay for knowledge on CCA in the research area are shown in Table 13. Similar to findings by Ouédraogo et al. (2018), the study revealed zthat several socio-economic and motivational factors such as gender, age, education level and awareness of CIS affected farmers' WTP for a climate information service in Burkina Faso.

As farmers increase in years, the study findings have shown that they tend to be risk-averse and desist from taking up new challenges to tackle climate change variability, hence would rather not invest in paying for CCA Information. This finding corresponded to those of Ouédraogo et al. (2018) which implied that the older the farmer, the less willing they were to pay. According to Pan, Smith and Sulaiman, (2018) Farmers with more years of experience in farming may have already developed their own adaptation strategies and may not see the need to invest in additional information or technology. On the other hand, those who have been farming for fewer years may be more willing to invest in new information and technology to inform their agricultural investments. These findings on the other hand contradicted with Mabe et al. (2014) and Zongo et al. (2015) in Ghana and Burkina Faso which stated that WTP tends to increase with an increase in farmer’s years.

The household’s main source of income was significant at 10% with a negative correlation to WTP. This finding contradicted findings by Aydoğdu et al. (2020); Doğan et al. (2020); Mabe et al. (2014), whose conclusion was that farmers with non-agricultural income tend to have a lower WTP probability. Instead, this study showed that farmers' over-reliance on farming as a source of income reduces their WTP. This can be attributed to farmers with alternative sources of income having more to spare for adaptation knowledge to strengthen farming and increase their food security situation. Whereas, farmers reliance on farming as the sole source of revenue had a low discretional income to invest in or pursue for information. According to the study's findings, 19.4% of the respondents indicated that they were unable to pay for knowledge on CCA because they were unwilling to do so. According to the World Bank Group (2019), residents in the area have an annual per capita income of 2,898 US dollars. However, households typically spend this money on consumption rather than production.

Higher education levels among farmers had an impact on their WTP for understanding of CCA, which is in line with the findings of Devkota et al. (2014), Ouédraogo et al. (2018), and Zongo et al. (2015). It should be highlighted that a farmer's ability to understand the importance of prior knowledge on CCA in agricultural decision-making increases with their level of adaptability and resilience.

Understanding and use of CCA information which was positively correlated with WTP, demonstrated that increased awareness and utilization of climate change information by smallholder farmers increased their WTP. Thus, to improve farmers' WTP, their awareness of what climate change adaptation was and its importance was crucial, and so was promoting the application of the information on-farm decision making. For instance, a 2009 study in Ethiopia by Deressa et al. indicated that farmers were more likely to implement adaption techniques and more prepared to pay for such information if they had a better awareness of climate change and its possible effects on their livelihoods. Similar to this, a 2017 study conducted in Bangladesh by Akter et al. discovered that farmers who were more aware of climate change were more likely to implement adaption measures and more prepared to pay for knowledge about them.

According to a study conducted in Ethiopia by Wossen et al. (2018), farmers who had already established measures for coping with climate change were more likely to be prepared to pay for additional information about CCA. According to the authors, these farmers were more open to investing in new knowledge to further their adaptation efforts since they were more aware of the potential advantages of adaptation tactics.

Similarly, farmers need to be aware of climate unpredictability in order to react and put adaptation techniques into action, as shown by Kibue et al. (2016). The length of exposure to CHAI directly impacted the decision to pay, according to Devkota et al. (2014), Mabe et al. (2014), & Zongo et al. (2015).

Effective dissemination of the Information had a positive significance in influencing a smallholder farmers WTP. This implied that when farmers received information on time and in a manner that they can comprehend, articulate and derive meaningful insight from, their WTP tend to increase significantly. The length of time by which a farmer has been exposed to this information on adaptation had a significant impact in explaining their WTP. Together with information utilization, which was significant at a 1% significance level with a positive correlation to WTP, it illustrated that experience in access and utilization of the information had a great role in influencing farmers'

WTP. Just as evident by findings from Devkota et al. (2014) and Mabe et al. (2014), farmers need to experience and experiment with the information to gain the confidence to pay.

The WTP of smallholder farmers was generally negatively impacted by the farmer's age. This can be linked to the fact that the bulk of elderly farmers have knowledge of different indigenous adaption strategies. This conclusion is supported by a study conducted in Uganda by Kato et al. (2018) who discovered that farmers' WTP for knowledge on climate change adaptation was significantly impacted negatively by age. The authors speculate that this might be the case because elderly farmers may still utilize more conventional farming methods and may be less open to implementing new methods and technologies to mitigate climate change.

*Table 13: Factors that affect farmers' willingness to pay to acquire knowledge about coping with climate change*

| **Dependent Variable**: Smallholder farmers' willingness to pay to access climate change adaptation information | | | |
|---|---|---|---|
| Independent Variables | Coefficient (β) | Std. Err (θ) | P |
| Household Head, Education Level | 0.398 | 0.2073 | 0.051 ** |
| Gender | 0.105 | 0.1634 | 0.521 |
| Age | -0.030 | 0.0075 | 0.000 *** |
| Household Size | -0.018 | 0.0129 | 0.531 |
| Farm Size | -0.004 | 0.0137 | 0.746 |
| Income source | -0.139 | 0.0723 | 0.052 ** |
| Farming Experience | 0.010 | 0.0069 | 0.135 |
| Understanding Climate Change Adaptation | 0.761 | 0.1608 | 0.000 *** |
| Access to Climate change Adaptation Information | 1.027 | 0.4748 | 0.031 ** |
| Information Access Period | 0.024 | 0.0118 | 0.042 ** |
| Climate Change Adaptation Information Usage | 0.753 | 0.1708 | 0.000 *** |
| Participation in Group | - 0.285 | 0.1891 | 0.132 |
| Proximity to Market | 0.480 | 0.1550 | 0.002 *** |
| Effective Dissemination of Information | 0.164 | 0.0434 | 0.000 *** |

*Note: Number of observations: 443 households, Omnibus test: Likelihood Ratio $\chi^2$ = 69.283, significant at 1% level (p = 0.000). ***, ** and * represents 1%, 5% and 10% significance level respectively.*

# CHAPTER FIVE:

# CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion

As illustrated from the results of the study, radio, climate field schools (CFS), and agricultural extension officers were imperative in disseminating CHAI. This is because the channels are considered reliable, accessible and informative by farmers. Farmers can discuss and improve their understanding when information is disseminated via groups and by extension experts.

The primary factors affecting smallholder farmers' access to information on CCA Kitui, Machakos, and Makueni have been the method of information dissemination, the efficacy of the information, and knowledge and understanding of the effects of climate change on production and food security. The vulnerable farmers are unable to acquire information through channels they are unfamiliar with, this prevents them from adapting.

Among the farmers who expressed the desire to pay to access CHAI who were the majority from the sampled farmers. The amount of farmer WTP was directly associated with their understanding of impacts of climate change, the effectiveness of the information, the age of the farmers, the period or experience in farming as well as their level of literacy. It can also be noted that the farmers with multiple source of income were highly interested in investing in farming through use of CHAI.

## 5.2. Recommendations for policy

The following recommendations were given based on the study's findings to help smallholder farmers in marginal areas like Kitui, Machakos, and Makueni Counties improve their capacity for adaptation and resilience:

If the county or national meteorological departments would increase on effectiveness of the information disseminated to smallholder farmers in terms of timeliness and specific in location, this will improve on access and utilization of the information thus resulting to proactive decision making while investing in agricultural ventures.

Awareness-creation and targeted messaging on climate change adaptation among smallholder farmers should be adopted by both local and national governments. Organization of farmers in groups such as climate field schools is encouraged to enhance easy access, understanding and application of climate change adaptation information.

Programs such as Climate Field schools should be set up and facilitated to increase farmers' access and understanding of the information. Besides, farmers should be encouraged to organize themselves into groups to enable easy and cheap access to this information.

County Governments need to develop a mechanism to enable the farmers pay for agro-advisory services in order to continue enjoying them without over-relying on donor support. Creating a county climate change adaptation kitty to help in climate change adaptation information generation and research would assist in enabling affected counties and reduce on donor funding.

### 5.3. Recommendations for further studies

Further study should be done to determine the effects of the programs and initiatives put in place to inform farmers about climate change adaptation on their food production and, in turn, food security.

In addition, a research might be conducted to estimate the expense and long-term gains of adopting the climate change adaptation program among smallholder farmers.

## CHAPTER SIX

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# APPENDICES

## Appendix 1

*Figure 6: Sample Climate change adaptation information document disseminated to farmers*

- Farmers are encouraged to use farmyard manure (FYM) and chemical fertilizers in consultation with agricultural extension officers, to improve soil fertility and increase crop yields. Planting and top-dressing with NPK and CAN, respectively, is recommended. They are also encouraged to diversify crops and farm enterprises to reduce risk.
- Rather than establish a new sorghum crop, farmers are encouraged to ratoon last season's crop, at a height of 1.5 cm above the ground
- Regular harvesting, baling and storage of grass/pasture for later use is strongly recommended

**Additional Information**

Following a successful October-November-December (OND) 2019 season, farmers are advised to dry their grain to 13.5% moisture content before storing it to avoid infestation by aflatoxin-producing fungi. Further, they are advised to watch out for storage pests and take appropriate control measures. Finally, they are encouraged to use certified seeds from reputed sources.

**Important Note**

The information provided here is general information based on the March-April-May (MAM) 2020 seasonal forecast issued by the Kenya Meteorological Department (KMD).
The information should be used in conjunction with the forecast updates issued by KMD and technical advice provided by the nearest agricultural extension office.

**This advisory is a collaborative effort of the following institutions**

Kenya Agricultural and Livestock Research Organization

University of Embu

Ministry of Agriculture, Livestock Development, Fisheries and Cooperatives

Kilimo Media International

Biovision Africa Trust

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IDRC | CRDI

**WEATHER-BASED AGRO-ADVISORY FOR MAKUENI COUNTY**

**MARCH-APRIL-MAY 2020**

Figure 7: Sample Climate change adaptation information document disseminated to farmers

**About this advisory**

This advisory was developed on 25th February 2020 by a team of subject matter specialists from Kenya Agricultural and Livestock Research Organization (KALRO), University of Embu (UoE), Biovision Africa Trust, Kilimo Media International (KIMI) and the Ministry of Agriculture, Fisheries, Livestock Development and Cooperatives with financial support from Canada's International Development Research Centre (IDRC) through the project **"Scaling-up Pathways of Last Mile Climate Information Services for Community Resilience in Kenya and Uganda"**

The advisory is mainly aimed at supporting farm level decision making in Makueni County in planning agricultural activities for the March-April-May 2020 Rain Season. Application of this advisory to other areas will depend on similarities in soil and climatic conditions of such places with those of Makueni County.

**Performance of the Oct-Dec 2019 Rain Season**

Like the rest of the country, Makueni County experienced heavy rainfall throughout the October-November-December season. Most rainfall stations in the county recorded above normal rainfall. Crop performance was exceptionally good. However, land and mudslides were experienced in some parts of the county leadings to loss of lives and destruction of property.

**Outlook for Mar– May 2020 Rain Season**

- Makueni County and its environs are expected to receive above normal (enhanced) rainfall
- Makueni County is expected to realize the onset in the first to second week of March 2020 and cessation in the second to third week of May 2020
- The March to May 2020 rainfall is predicted to be well distributed
- The peak of the rains is expected to be in the month of April 2020

**Implications of the Forecast on Agriculture**

Based on the above outlook:

- Farmers are advised to plant crops of their choice at the earliest opportunity by dry planting after preparing the farm in the 1st week of March 2020
- They are advised to repair their terraces and desilt existing dams and water pans before the on-set
- Farmers are encouraged to plant the following crops:

| Target Area | Crop | Recommended Variety | Correct Spacing |
|---|---|---|---|
| **Upper zones** (Mbooni Hills, Kivani, Makongo, Kilungu Hills & Iuani) | Beans (*Mbooso*) | Rosecoco, Nyota, KATX56,KAT X69 | 45cm x 20cm |
| | Maize (*Mbemba*) | High yielding hybrid varieties such as DH 04 | one plant per hill at 90cmx30cm or two plants per hill at 90cmx60 cm |
| | Sweet potatoes | Orange fleshed variety (SPK 004) | 75cm x 50cm |
| | Pasture grasses (*Nyeki*) | Bracharia, Bana grass, Napier grass (*Kitothya*) | |
| **Mid-zones** (Wote, Matiliku, Mbitini, Nzaui, Kilili, Emali, Kilome, Sultan Hamud, Kasikeu, Kiima Kiu, Kilala, Ukia, Kee, Kaumoni, Mbumbuni and Kisau) | Beans (*Mbooso*) | KAT Bean 1 | 45cm x 20cm |
| | Maize (*Mbemba* | High yielding hybrid varieties eg DH 04 & others as may be recommended by agricultural extension officers | one plant per hill at 90cmx30cm or two plants per hill at 90cmx60 cm |
| | Cowpea (*Nthooko* | M66 | 60 m x 20cm |
| | Dolichos (*Mbumbu* | DL 1002 | 50cm x 50cm |
| | Finger millet (*Wimbi*) | KAT FM-1 | 30cm x10cm |
| | Pearl millet (*Mwee)* | KAT PM 1 KAT PM 3 | 60cm x 15cm sole crop & 120cm x 15cm when inter-cropped with a row of legume |
| | Sorghum (*Muvya)* | Gadam, Seredo, Serena KARI Mtama 1 | 60cm x 20cm sole crop & 120cm x 15cm when inter-cropped with a row of legume, |
| | Pasture grasses (*Nyeki*) | Rhodes grass, Bana grass,Bracharia,Napier grass(*Kitothya)* | |
| Lower zones Kathonzweni, Mavindini, Kitise, Kalii, Kiboko, Makindu, Kibwezi, Mtito Andei, Ngwata & Kalawa) | Green grams (*Ndakithi, Ndengu*) | N26, KS20, Bi-ashara, Ndengu Karembo | 45cm x 15cm |
| | Cowpeas (*Nthooko* | KVU27-1, K80 | 60 m x 20cm |
| | Maize (*Mbemba*) | Use open pollinated varieties such as KDV 1 and others as may be recommended by the agricultural extension officers | one plant per hill at 90cmx30cm or two plants per hill at 90cmx60 cm |
| | Dolichos (*Mbumbu)* | DL 1002 | 50cm x 50cm |
| | Finger millet (*wimbi)* | KAT FM-1 | 30cm x10cm |
| | Pearl millet (*Mwee)* | KAT PM 1,3 | 60cm x 15cm sole crop & 120cm x 15cm when inter-cropped with a row of legume |
| | Sorghum (*Muvya*) | Gadam, Seredo | 60cm x 20cm sole crop & 120cm x 15cm when inter-cropped with a row of legume, |

- For those with fruit (mango,avocado and orange) orchards or bananas, we advise that they prune, cut & burn or bury fruit stalks, add manure and construct *negarims* and *semi-circular bunds* around them to harvest water, before the start of the season
- Farmers are advised to watch out for aphids (*umuu*)

especially in cowpea and fruit trees; Fall Army Worms (*Kiinyu*), stem borers and termites in maize; shoot fly and stalk borers in sorghum; Anthracnose in beans; scab;*(Kikaa)*; borers and bugs in pigeonpea; locusts and report such outbreaks to agricultural extension officers

- Livestock farmers are advised to look out for Lumpy Skin *(Makundu)* and Foot and Mouth *(Muthingithu)* Diseases and report such outbreaks to the nearest agricultural extension office
- Poultry farmers should look out for viral diseases, especially the Newcastle Disease (NCD), and vaccinate their birds in time

# Appendix 3: Research Questionnaire

https://kf.kobotoolbox.org/#/forms/aSQW38D7LWPYbX4BPCQS7q/summary