



ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR ENVIRONMENT AND DEVELOPMENT STUDIES

DETERMINANTS OF CLIMATE INFORMATION SERVICE TO ENHANCE  
SMALLHOLDER FARMERS CLIMATE ADAPTATION: A CASE OF BEREH

WOREDA, OROMIA REGION, ETHIOPIA

BY

TSION FIKADU

ADVISOR: SHIMELES DAMENE (PH.D.)

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Determinants of Climate Information Service to Enhance Smallholder Farmers

Climate Adaptation: A Case of Bereh Woreda, Oromia Region, Ethiopia

By

Tsion Fikadu

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Advisor

Shimeles Damene (Ph.D.)

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**School of Graduate Studies**

This is to certify that the thesis prepared by Tsion Fikadu entitled “Determinants of access and use of climate information services among smallholder farmers: A case of Bereh Woreda, Oromia region, Ethiopia” submitted in partial fulfillment of the requirements for the Degree of Master of Art in Environment and Sustainable Development complies with the regulations of the University and meets the accepted standards concerning originality and quality.

Signed by the Examining Committee:

External Examiner \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

Internal Examiner \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

Advisor \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

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## DECLARATION

This is to declare that this thesis work entitled “**Determinants of access and use of climate information services among smallholder farmers: A case of Bereh Woreda, Oromia region, Ethiopia**” submitted in partial fulfillment of the degree of Master of Arts in Environment and sustainable development. This is my original work and has not been presented for an award of a degree in any other university. All resources of material used for this thesis have been properly acknowledged.

Tsion Fikadu Nigussie

Signature\_\_\_\_\_

Date\_\_\_\_\_

<b>TABLE OF CONTENTS</b>	<b>Page</b>
ACRONYMS.....	viii
ACKNOWLEDGMENT .....	ix
ABSTRACT .....	x
CHAPTER ONE .....	1
1. INTRODUCTION .....	1
1.1. Background .....	1
1.2. Statement of the problem .....	3
1.3. Objectives .....	4
1.3.1. General objective.....	4
1.3.2. Specific objectives .....	4
1.4. Research questions.....	4
1.5. Significance of the study .....	5
1.6. Scope of the study.....	5
1.7. Limitation of the study .....	5
1.8. Organization of the study .....	6
CHAPTER TWO.....	7
2. LITERATURE REVIEW.....	7
2.1. Definition of terms .....	7
2.2. Climate change in Ethiopia .....	7
2.3. Climate Information Service .....	9
2.4. Climate information services in Ethiopia .....	10
2.6. Access and use of climate information Service .....	12
2.6.1. Access to climate information service .....	12
2.6.2 Climate information dissemination channels .....	12
2.6.3. Use of climate information service .....	13
2.7. Climate information service for climate adaptation.....	13
2.8. Review of empirical studies on factors influencing access and use of climate information service .....	14
2.9. Conceptual Framework.....	14
CHAPTER THREE.....	16
3. METHODOLOGY .....	16
3.1. Study area description .....	16

<b>3.2. Research design</b> .....	19
<b>3.3. Data types and Sources</b> .....	19
<b>3.4. Sampling procedure</b> .....	19
<b>3.5. Data collection</b> .....	20
<b>3.6. Data Analysis</b> .....	20
<b>3.7. Theoretical model Estimation</b> .....	21
<b>3.8. Econometric Specification</b> .....	22
<b>3.9. Statistical tests for Heckprobit model</b> .....	23
<b>3.10. Justification of Variables of the model</b> .....	24
<b>3.10. Ethical Consideration</b> .....	26
<b>CHAPTER FOUR</b> .....	27
<b>4. RESULTS AND DISCUSSION</b> .....	27
<b>4.1. Socio-economic characteristics</b> .....	27
<b>4.2. Smallholder Farmer’s Practice to Climate Information Services</b> .....	29
<b>4.3. Determinants of smallholder farmers access to Climate Information Services</b> .....	33
<b>4.4. Determinants of smallholder farmers Climate Information Services use</b> .....	35
<b>CHAPTER FIVE</b> .....	39
<b>5. CONCLUSION AND RECOMMENDATIONS</b> .....	39
<b>5.1. Conclusion</b> .....	39
<b>5.2. Recommendation</b> .....	40
<b>REFERENCE</b> .....	41
<b>APPENDICES</b> .....	53

## Figures

Figure 1: Conceptual framework of the methodological techniques of the study .....	15
Figure 2: Location map of the study area .....	16
Figure 3: Climate variability indicators identified by households .....	29
Figure 4 : Source of CIS .....	30
Figure 5: Households level of extent perceived CIS important .....	32

## Tables

Table 1: The summary statistics for independent variables .....	24
Table 2: Socioeconomic Characteristics of household sample.....	27
Table 3: Types of weather forecast frequently accessed by smallholder farmers .....	31
Table 4: Summary of climate information dissemination channels.....	32
<i>Table 5: Results of the Heckman probit selection model for access to CIS .....</i>	<i>35</i>
<i>Table 6: Result of the Heckman selection model for farmer's use of CIS.....</i>	<i>37</i>

## ACRONYMS

CIS	Climate Information Services
CRGE	Climate Resilience Green Economy
CSA	Central Statistics Agency
ECA	Economic Commission for Africa
EPA	Environmental Protection Authority
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
GHG	Green House Gases
GTP	Growth and Transformation Plan
ILA	International Labour Organization
INDC	Intended Nationally Determined Contribution
IPBES	Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel for Climate Change
NAP	National Adaptation Plan
NAPA	National Adaptation Program of Action
NGO	Non-Governmental Organization
NMA	National Meteorological Agency
SMS	Short Messaging System
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan African
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate change
WBG	World Bank Group
WCIS	Weather and Climate Information Service
WHO	World Health Organization

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## **ABSTRACT**

*Climate information service (CIS) is a key component of a climate adaptation strategy which is expected to lessen climate risk. Access and uses of CIS among the local community are limited and constrained by various factors and are not supported by empirical research evidence. Therefore, the study analyzed CIS determinants for climate adaptation among smallholder farmers in Bereh Woreda. The study applied a two-stage sampling where, two kebeles purposively selected based on agro-ecological zone criteria and in the second stage systematic sampling technique was used to select sample size of 219 households. Household surveys, focused-group discussions (FGDs), and key informant interviews were used to collect data. Descriptive statistics and the Heck-probit model were employed for data analysis. Result of the heckprobit model selection equation revealed that age the household (HH), off-farm income, and smallholder farmers' exposure to recurrent floods significantly reduced the likelihood of accessing CIS, whereas; mobile ownership and gender of HH increased the likelihood of accessing it. Age of HH, gender of HH and farm size had reduced the likelihood of using CIS, whereas mixed farming, radio ownership and access to herbicide enhanced the likelihood of using CIS. This study, therefore, recommends improving the timely delivery of diverse and reliable CIS to enhance smallholder farmers' climate adaptation.*

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**Keywords:** Access, Bereh, Climate Adaptation, CIS, Use

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1. Background

Climate change is critically threatening sustainable development at global level which is significantly affecting nature and people (World Bank, 2010). Recurrent flood, variation in rainfall pattern and intensity, recurrent drought (UNFCCC, 2007), biodiversity loss (IPBES, 2019), high rate of soil erosion, and agricultural productivity reduction (Girmay *et al.*, 2021) are few of the observed impacts. These all are aggravating food security (World Bank, 2022), and exacerbating the increased outbreak of pandemic and epidemic diseases (Swinburn *et al.*, 2019).

Globally nearly 690 million people suffer from severe hunger due to climate change (Zougmore *et al.*, 2021). The important climate-sensitive economic sectors in developing countries such as agriculture have been mainly affected (IPCC, 2007). The ability to foresee and respond to the impacts is hindered by limited institutional, human, and financial capacity (Gagnon-Lebrun and Agrawala, 2006). The African economy highly relies on agriculture, which employs between 60%-90% of the labor (Mohammed, 2020). According to Ahmed *et al.* (2016); and Anderson and Gershon (2007), most of the population in Sub-Saharan Africa (SSA) relies on rain-fed and traditional farming for subsistence livelihoods.

Like most African countries, Ethiopia's economy relies on agriculture with an estimated contribution of about 42% to the national GDP (CSA, 2018). About 80%-85% of the population is subsistence farmers (Hamza and Iyela, 2012). The agriculture sector is vastly vulnerable to impacts of climate change due to rainfall dependency, geographical location, and lower adaptive capacity. The prime reasons for the lesser adaptive capacity include level of poverty, poor infrastructure development, less access to irrigation, and reliance on the natural resources of impoverished people (Alemu and Mengistu, 2019). Climate adaptation must be enhanced to reduce smallholders' vulnerability to climate change impacts (Roopam *et al.*, 2021).

Among the 17 UN Sustainable Development Goals (SDGs) adopted in 2015; Goal 13 has specifically considered the issue of climate change by calling for urgent actions to strengthen resilience and adaptive capacity (UN, 2015). Further parties have been forced to integrate

climate change actions into national policies and improve education on climate change mitigation and adaptation (UN, 2015). The Ethiopian government has developed several strategies, plans, and initiatives to reduce the country's vulnerability to climate risks such as; Climate Resilient Green Economy (CRGE), National Adaptation Plan (NAP), National Adaptation Program of Action (NAPA), and Intended Nationally Determined Contribution (INDC). Technologies play an important role to implement strategies in order to enhance resilience and adaptation to climate change.

Climate adaptations in agriculture have been linked with access to climate and weather information. Weather and climate information services are the foundation to enable adaptation and build resilient agriculture towards the impacts of climate change (Seneshaw *et al.*, 2022). Effective climate adaptation is hampered by inadequate climate information (Muema *et al.*, 2018). Adequate climate information is considered in the availability, accuracy, and timeliness of predictable weather conditions and knowledge and skills to adapt to the changing climate (Anni, 2019). Access to timely and reliable climatic information services (CIS) is a requirement as an adaptation initiative for agricultural productivity and risk reduction (Abdul *et al.*, 2022).

CIS refers to the process of producing, interpreting, disseminating, and use of scientific climate information for decision-making (Bessah, *et al.*, 2021). Providing such information helps smallholder farmers make well-versed decisions for farmland preparation, planting time, crop variety, harvesting, and marketing seasons. Access and proper use of CIS highly improve and increase farmers' adaptive capacity (Le, 2021; Seneshaw *et al.*, 2022). A recent study by Seneshaw *et al.* (2022) reported that access to CIS enhanced farmers' resilience in Ethiopia. Despite the need for such information being recognized, the potential benefit is not being realized due to several restrictions regarding access and use of this information (Getachew, 2015).

Ethiopia's National Meteorology Agency (NMA) is the main source of CIS in (Dinku *et al.*, 2011). NMA is responsible and mandated to collect and manage the provision of meteorological and climate services (Lemma and Ketema, 2018). CIS disseminated through agricultural extension workers, media such as newspapers, radio, television, internet, and various digital platforms. The service provision is undeniable, but the emphasis is not well given on implementing climate information to manage climate risk and vulnerability reduction. Technical,

social, and psychological factors are the most important challenges of CIS access and use (Serra and Mckune, 2016).

## **1.2. Statement of the problem**

Smallholder farmers in SSA have limited access to CIS which has greatly hampered the use of climate information (Muema *et al.*, 2018). Therefore, the capability of smallholder farmers to adapt to climate change is also influenced by their access to CIS (Bryan *et al.*, 2009). According to Getachew (2015), farmers' adaptation capacity is highly constrained in utilizing the accessible CIS. This indicates that provision of CIS is not sufficient to adapt to climate change unless it is complemented with actual use.

Indigenous climate and weather forecasting practices are the main source of climate information in Ethiopia (Mulubrhan, 2016). However, depending only on this traditional practice may lead to unexpected predictions as climate change is highly unprecedented. Therefore, it is a wise approach to combine the traditional practice with a modern CIS. The scientific CIS has been used as a critical tool for climate adaptation strategy in Ethiopia for over two decades; particularly applied for early warning and drought management interventions (Hellmut *et al.*, 2007).

Study by Dinku *et al.*, (2011) has reported that availability of CIS has not necessarily led to effective access and use. However the study has a gap on measuring and identifying the level of CIS access and use among smallholder farmers. Seneshaw *et al.*, (2022) reported that in Ethiopia only 10% of the districts (Tesfaye *et al.*, 2019) and 18% of farmers have access to CIS, despite its longer CIS availability. Nevertheless, there is a gap on identifying the factors that are influencing farmers' access to CIS. In fact, capacity to adapt to climate change is unequal across and within societies (Gebru, 2014). Thus, it is crucial to understand the local socio-economic factors that determine farmers' access to and their capacity to use CIS (O'Brien *et al.*, 2000).

The Bereh Woreda in the Oromia regional state of Ethiopia is among the vulnerable districts to climate change impact in the country (AAWSA, 2011). The area has experienced rapid conversion of natural land into cultivation and settlement due to increasing population growth (AAWSA, 2011; 2016). Climate variability have an impact on the overall ecosystem services including soil formation and nutrient recycling in the Dire and Legedadi watersheds of the Bereh woreda (Admasu *et al.*, 2023).

There is a lack of prior empirical and theoretical assessment conducted to determine the level of smallholder farmers' access and use of CIS in the study area. Therefore, this study was conducted in Bereh Woreda for three major reasons. First, because of the higher annual agricultural yield variation obtained between agriculture research centers and smallholder farmers due to differences in agricultural technology applications for climate adaptation (OWWDSE, 2011) in which research centers obtained double yield per hectare smallholder farmers (OWWDSE, 2011). Second, 62% of woreda livelihood remains firmly mixed agriculture, and 68% of the population is below the poverty line, earning a monthly wage of 500 Birr (OWWDSE, 2011). Thus, the agricultural practice in the study area needs to be supported with climate adaptation mechanisms. Finally, the study area has experienced several natural disasters including landslides, land degradation, soil erosion, and lower land productivity that have impacted the entire ecosystem of the woreda including the major water reservoirs (Dire and Legedadi) of Addis Ababa city (AAWSA, 2011; 2016; Admasu et al., 2023) and significantly affecting the livelihood of the smallholder farmers. Therefore, smallholder farmers' access and use of CIS could contribute to halting the adverse impact of climate-related hazards and improve their adaptation capacity to climate change impacts.

### **1.3. Objectives**

#### **1.3.1. General objective**

The general objective of this study is to analyze factors determining smallholder farmers' access to and use of CIS in Bereh Woreda Oromia region, Ethiopia.

#### **1.3.2. Specific objectives**

- To assess smallholder farmers **CIS practice**;
- To identify determinants of smallholder farmers **access** to CIS;
- To identify determinants of smallholder farmers **use** of CIS.

### **1.4. Research questions**

1. How farmers perceived and practicing CIS in the study area?
2. What are the factors affecting smallholder farmers' access to CIS?

3. What are the factors affecting smallholder farmers' CIS use?

### **1.5. Significance of the study**

This study has assessed and generates information on the factors that affect smallholder farmers' access to and use of CIS in the study area. Thus, the findings from this study are expected to contribute valuable inputs for policy and decision-making processes. Further, it can be used to develop sound planning and management endeavors of CIS that can be applied by development agencies, government, and non-government organizations to address the challenges that hindered farmers' access and use of CIS. Finally, this study will contribute to fulfilling the Intergovernmental Panel for Climate Change (IPCC) initiative that pays adequate attention to research projects aimed at improving farmers' adaptive capacity in Africa.

### **1.6. Scope of the study**

This study was thematically restricted on the analysis of the factors that are determining smallholder farmers' access to CIS and their utilization in farm decision making. Spatially the study case was undertaken in the Bereh Woreda, Oromia region of Ethiopia. Further, the study was bounded methodologically and target population. It has explored the different sources of CIS and identifies the determinant factors influencing smallholder farmers' access and use of CIS.

### **1.7. Limitation of the study**

This study has been limited to capture direct information from smallholder farmers due to language translation has been done during data collection. Financial constraints and time boundary has limited the study to focus on two kebeles and smallholder farmers involved only in mixed agricultural activities. Unwillingness of female headed households to participate in focused group discussions (FGDs) has limited to undertake FGDs with only male headed households. Collecting organized and updated secondary data documents was very challenging due to poor culture of registering and documenting relevant information at least what is practically done. Moreover, the study has not analyzed the smallholder farmer's knowledge and perception towards CIS which could be a limitation to be considered for further studies in the future.

## **1.8. Organization of the study**

This research thesis has five chapters. **Chapter One** presents the introductory section of the thesis. In **Chapter Two** literature reviews are presented in which the available theoretical, empirical knowledge, and conceptual framework on climate-related information was briefly discussed. **Chapter Three** contains the methods of the study including the research design, method of data collection, sampling procedure, and data analysis techniques. In **Chapter Four** the main findings of the study are presented with brief discussion. Finally, in **Chapter Five**, the study conclusion and recommendations were provided.

# CHAPTER TWO

## 2. LITERATURE REVIEW

### 2.1. Definition of terms

**Climate Change** is referred to as alterations in the composition of the global atmosphere that may be ascribed directly or indirectly to human activities, and which is in addition to natural climate variability observed over extended time periods (IPCC, 2001).

**Adaptation** is the adjustment in human or natural systems in response to actual or expected climatic incentives or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

**Climate change adaptation** is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

**Climate information** referred as to the collection and interpretation of the actual weather and climate observations and simulations in both past and future periods (Baffour *et al.*, 2022).

**Climate information Services** is a provision of climate information in a way that assists farmers and organizations to make scientific forecast-based decisions with effective access mechanisms (Tall *et al.*, 2018; Lugen, 2017; Machingura *et al.*, 2018).

### 2.2. Climate change in Ethiopia

Since 1970, Ethiopia has been affected by the impacts of climate change and it has become a key concern that seriously needs to be tackled (Belay and Getaneh, 2016). Recurrent draught is the country's major climate change-induced hazard threatening rural livelihoods and food security. These have caused loss of life and property as well as displacement of people (Simane *et al.*, 2016). According to Mohammed (2020) and NMA (2001), climate change is noticeable and manifested through an increase in average temperature, and variability of rainfall and its distribution that can cause natural hazards. The temperature has shown an increment by an average of 1°C, at an average rate of 0.25°C -0.4°C per decade between 1960 and 2006 (BFA, 2009; WBG, 2021). Even though there is a lack of records rainfall trends over time, show high

variation (Belay and Getaneh, 2016; BFA, 2009). A study by Kidanu *et al.*, (2009) projected that there would be 3.1°C-5.1°C rise of annual temperature by 2060-2090 and 1.97 mm/day decrease in average annual precipitation by 2070-2099. In addition UNDP (2011) has also reported that global climate change in Ethiopia could lead to extreme temperatures and rainfall events, causing more heavy and extended droughts and floods. This could cause food insecurity, an outbreak of diseases such as malaria, dengue fever, cholera and dysentery, malnutrition, land degradation, and damage to infrastructure (Zeray and Demie, 2015).

Ethiopia contributes around 150 Mt c which is less than 0.3% of global emissions (Berhanu *et al.*, 2019). However, the adverse impacts of climate change brought by the carbon-intensive development paths of rich countries have been affecting the country over the past century (Mohammed, 2020). Studies revealed that the agriculture sector contributes more than 80% of the Green House Gases (GHG) emissions in Ethiopia due to the dominant position of livestock production has influenced high methane emissions (Negussie and Ashebir, 2015; Ademe *et al.*, 2021; WBG, 2021). This has led the sector and livelihood of subsistence farmers and pastoralists become more susceptible to climate change impacts (Belay and Getaneh, 2016).

Ethiopia is vulnerable to climate change impacts with the least adaptive capacity (NMA, 2007; Negussie and Ashebir, 2015). According to IPCC (2007), the impact may potentially hold back economic progress or reverse the gain made in the development and exacerbate socio-economic challenges. This is due to different interlinked factors such as poverty, high population growth, over-exploitation of natural resources, and subsistence of rain-fed agriculture. Thus, the impact in reducing agricultural production has made Ethiopia one of the biggest food aid recipient countries in Africa which accounts for 20-30% of all food aid to SSA (Bezu and Holden, 2008).

Thus, efforts to enhance the resilience to climate shocks of agricultural production should be improved by Adaptation. Adaptation is lessening the negative effects of current or future climate change while maximizing the benefits (IPCC, 2007). The government of Ethiopia has put several documents, policies, strategies, and programs in place including the Plan for Accelerated and Sustainable Development to End Poverty, National Adaptation Programs of Action (NAPA), the Environmental Policy, and the Agriculture and Rural Development Policy and Strategy (Belay and Getaneh, 2016). These strategies and programs aim to enhance the adaptive capacity and reduce the vulnerability of the country to climate variability and change (Belay and Getaneh,

2016). Moreover, to ensure the adaptation efforts are carried out successfully, NAPA developed a participatory procedure and integrated climate change adaptation efforts with national development policies (UNFCCC, 2007). Thus, adaptation mechanisms can increase the resilience of the agriculture sector that leads to achieving the food security programs and Ethiopia's national growth and transformation plan in general.

### **2.3. Climate Information Service**

CIS emerged in response to the fact that improving climate information has not always resulted in effective adaptation (Vincent *et al.*, 2018). The content of CIS includes reliable weather and climate information distribution as well as several supportive advisory services for decision makers in understandable manner in order to respond for the information in a relevant working context (Alexis, 2022). A CIS must examine and involve users in order to enhance their interest, as well as incorporate them in designing and evaluating the services and products and development of building appropriate communication channel (Singh *et al.*, 2017). It also helps users to prepare for future projected experiences.

WMO (2021) reported that science-based climate information is crucial to reinforce resilience, bolster adaptation to climate change and maintain sustainable livelihood and development. In terms of sustainability, the value of CIS anticipated in economic, environmental and social status (Alexis, 2022). Environmental benefits gained through efficient use of CIS enhance the capability of mitigating weather and climate risk in the environment (Warner *et al.*, 2022). The economic benefits gained through adjusting managements in a way that increase outputs and reduce production cost. The social benefits for instance among smallholder farmers includes, improvements in farm practices and preparation of farming operations (Alexis, 2022).

CIS involves a projection of brief-term climate parameters such as daily weather forecasts on temperate and rainfall variability, seasonal climate outlooks which provide climate information, and long-term projections that incorporate decadal, multi-decadal, and centennial time scales that provide climate statistics on temperature, precipitation, relative humidity, and wind (Muema *et al.*, 2018; Singh *et al.*, 2016).

One of the initial responsibilities for the climate information services team and the consortium as a whole was to develop a set of agreed-upon ‘CIS standards’ (Alexis, 2022). According to Alexis (2022), the principles of ‘CIS standards’ are as follows:

- (i) The production of accurate information
- (ii) Using and interpreting probabilistic and unreliable information
- (iii) Useful information in terms of timely delivered and tailored to specific users
- (iv) Adequate CIS availability and two-way access
- (v) Collaboration of all the above and sharing with local community in a participatory manner.

#### **2.4. Climate information services in Ethiopia**

Most rural communities in Ethiopia's dry lands have relied on indigenous climate and weather forecasts for centuries to cope with climatic stressors (Tilahun, 2020). However, climate change and variability are exposing these communities to extremes and challenging their ability to respond in a timely and sustainable manner (ALP, 2017).

The first scientific climate forecast was publicized in Ethiopia by NMA as a response to the impacts of El Niño in 1997 (Wolde-Georgis et al., 2000). The main sources of climate information are the numerous stations created by NMA. There are about 1300 ground weather stations and more than 157 automatic weather stations installed throughout the country (NMA, 2017). The NMA provides analyzed weather reports and forecasts on a daily, decadal, monthly, and seasonal basis. The Federal Agro-met Technical Task Force advisories which were established in 2016 by comprising the Ministry of Agriculture and Natural Resources (MoANR), NMA, Ethiopian Institute of Agricultural Research (EIAR), and Agriculture Transformation Agency (ATA) is responsible to translate the weather information into agro-meteorological advisories (Tesfaye et al., 2019). The data and services provided have many shortcomings such as the distribution of stations, data quality, missing observations, and problems with data access and use (Dinku et al., 2014). This has significantly abated the use of the available climate data. Moreover, there is still uneven distribution of stations across most lowlands areas of Ethiopia and most of the stations are in cities and towns along the main roads (Dinku et al., 2011). This has caused considerable limitations in the availability, access, and use of CIS in impoverished rural communities.

## **2.5. Sources of climate information services**

There are various sources of climate information in Africa including national meteorological and hydrological services, Intergovernmental Authority on Development (IGAD) climate prediction and application center, the global framework for climate services, and the African center for meteorological application development (Muema et al., 2018). In addition, Global Framework for Climate Service (GFCS) in collaboration with National Meteorological and Hydrological Services, Climate Change Agriculture and Food Security (CCAFS) under the Consultative Group on International Agricultural Research (CGIAR) offers services in Africa to improve readiness, promote food security, and improve health. In Ethiopia, NMA is mandated to provide quality and accurate meteorological data such as various weather forecasts and climate bulletins to users. Moreover, NMA produces agro meteorological bulletins that provide weather information, maps of rainfall intensity, weather outlook, vegetation conditions and impact on agriculture, and expected weather impact on agriculture. NMA collect climate data through the network of weather stations established across the country. The station numbers are increasing throughout the country however the distribution is uneven (Dinku et al., 2011). Even though records exist, they usually include data gaps, poor quality, and are frequently difficult to obtain. The customary report produced by NMA is disseminated to NGOs throughout the country with information counting precipitation dissemination and weather forecasts (Cochrane and Singh, 2017).

Indigenous climate forecasts are also sources of climate information for smallholder farmers in rural areas (Vogel and Brien, 2006). Farmers usually use indigenous climate information to make farm decisions, for soil and water conservation, and for food production and preservation (Roncoli and Ingram, 2002). Indigenous climate forecasts are location specific that can be predicted through observation and interpretation of natural phenomena, for instance, flowering and shedding of leaves, direction, and strength of winds, and behavioral changes of animals and insects (Muema et al., 2018). Due to climate variability and various challenges, it is not reliable to solely depend on indigenous climate forecasts. For instance, climate indicators such as birds, mammals, and plants are disappearing due to the destruction of their natural habitat; therefore, indigenous people do not find such natural indicators (Chang'a et al., 2010). However, the integration of indigenous climate information sources with scientific forecasts is advisable for better climate change adaptation (Russo et al., 2013).

## **2.6. Access and use of climate information Service**

### ***2.6.1. Access to climate information service***

The Global Framework for Climate Services was established in 2009 and has been operational since 2012 with a mission to facilitate timely access to climate services (Antwi-Agyei *et al.*, 2021). Access to CIS reduces the impacts of climate change and increase farmers' ability to cope with climate change and unpredictability (ECA, 2021). Access to weather forecasts can help farmers undertake farming activities effectively (Guido *et al.*, 2020; Djido *et al.*, 2021). Furthermore, access to CIS in Africa is anticipated to assist climate-sensitive sectors in coping more effectively while enhancing resilience and standard of living (Serra and Mckune, 2016). CIS is more available in East and Southern Africa than in Central and West Africa (Anni, 2019). However, the availability of data may not necessarily lead to access (Dinku *et al.*, 2011).

Although the need for CIS is growing for agriculture and other sectors, most African farmers have limited access. For instance, access to CIS increased maize and wheat productivity in Ethiopia, however only 18% of the smallholder farmers have access to CIS (Seneshaw *et al.*, 2022). Ensuring the sustainability of agricultural production becomes difficult without accessing appropriate climate and early warning information (Mudombi and Nhamo, 2014). Thus, the adoption of climate-smart agriculture technology by smallholder farmers is significantly hampered by the inaccessibility of CIS (Muema *et al.*, 2018).

### ***2.6.2 Climate information dissemination channels***

CIS-delivering channels are a crucial element of climate service communication. According to World Bank (2016), routes for disseminating climate information should be easily accessible and user-friendly in terms of accuracy, timeliness, affordability, language, and reliability. The dissemination channels for climate information can influence the access and use of CIS (World Bank, 2016). The key modes of CIS distribution include newspapers, bulletins, radio, television, trained intermediaries, short message service (SMS), internet, mobile phone applications, digital platforms, farmer organizations, and agricultural extension agents are widely used at the global level (WBG, 2016). Radio is the most preferred dissemination channel among farmers and pastoralists in developing countries (Muema *et al.*, 2018; Seneshaw *et al.*, 2022; Hampson *et al.*, 2014). Recent studies revealed that smallholder farmers are interestingly using mobile phone

services such as SMS, calls, voicemail, or the Internet to receive weather information (Rosaine and Janvier, 2021). In Ethiopia, different platforms such as ‘‘Lersha’’ and ‘‘Digital Green’’ are also providing climate information and agro-advisory services to farmers using extension agents in a digitalized way (CGIAR, 2021). This is very challenging and rarely acceptable in rural Ethiopia due to the low literacy rate and mobile access (Seneshaw *et al.*, 2022). Moreover, farmers in rural areas prefer indigenous information to scientifically generated information (Muema *et al.*, 2018).

### ***2.6.3. Use of climate information service***

Farmers use CIS in farm decisions making to reduce the impact of climate change on agricultural production (Patt *et al.*, 2017). High-quality data and good access may not ensure the effective use of climate information (Dinku *et al.*, 2011). Despite growing access to CIS in Africa, the use for adaptation is remaining very low (CIASA, 2015). Therefore, enhancing user awareness is essential. Limited accesses to CIS, lack of trust between producers and users, and poor capacity to interpret and apply information to agricultural needs are the prime factors influencing the use of CIS in Africa (Muema *et al.*, 2018). Further, socio-economic factors, including land availability, high illiteracy levels, access to credit, and market-constrained African farmers being the CIS user in decision-making (Klopper *et al.*, 2006; Coulibaly *et al.*, 2017).

## **2.7. Climate information service for climate adaptation**

CIS is a crucial tool that support smallholder farmers’ decision-making for climate adaptation and sustainability (Olga *et al.*, 2020). Previous research has revealed that having access to CIS improves farmers’ awareness of climate change, and their ability to adapt better management techniques and climate variability (Belay and Fekadu, 2021; Juan, 2018; Ng’ombe *et al.*, 2020). CIS improves farmers’ coping mechanisms against climate change by changing crop variety, farmland, livestock, water, and several management practices (Bryan *et al.*, 2011). In addition to this, smallholder farmers that have access to CIS, especially seasonal and sub-seasonal scale forecasts, are more likely to implement climate adaptation strategies, such as late or early planting, use of early maturing crops, agroforestry techniques, and soil and water conservation measures (Belay *et al.*, 2017; Dewi and Whitbread, 2017).

## **2.8. Review of empirical studies on factors influencing access and use of climate information service**

Several studies have been conducted to identify the factors that influence farmers' access to and use of CIS across Africa. For instance, Muema *et al.*, (2018), analyzed determinants of seasonal CIS access and utilization among smallholder farmers in Makueni County Kenya, where the study indicates access to CIS decreases with age increases, whereas, household size, income, and farm size, have a direct relationship with CIS. Similarly, Ouedraogo *et al.*, (2021) reported that age, level of education, being in farmer's associations, and owning a radio have a significant effect on triggering farmers to use CIS for decision-making in Senegal. A study by Buckland and Campbell, (2021) showed that gender, age, access to extension services, participation in farmer's associations, income, and farm size have significant effects on access and use of CIS in Clarendon Jamaica.

In the Limpopo River basin of South Africa, factors influencing access to climate forecast sources have been assessed by Oyekale, (2012). The study revealed that ownership of television, cars, radio, land, previous exposure to hailstorms and floods, and education level increased the likelihood of access to climate forecasts (Oyekale, (2012). Conversely, farming experience, household size, large farm size, and access to fertile land reduced the likelihood of access to climatic forecasts (Oyekale, 2012). The uptake of seasonal forecasts was reduced due to conflicts and insecurity, culture, lack of information, and diversified income source in the Baringo County of Kenya (Ochieng *et al.*, 2017).

## **2.9. Conceptual Framework**

The foremost factor in the adaptation to climate change is access and use of CIS (Ngigi and Muange, 2022). According to Ouedraogo *et al.*, (2018), CIS plays a significant role in influencing farmers' decision-making to modify crop management practices and livelihood diversification to reduce their vulnerability to climate change impacts.

Besides to the scientific CIS, indigenous weather forecasts are source of climate information for majority of the rural communities which is a traditional mechanism of climate adaptation. Due to the higher climate variability, solely depending on indigenous climate indicators become unreliable (Oyekale, 2012). This has led to the need for scientific weather forecasts. The NMA is

the only authorized agency that generates and provides scientific weather and climate data in Ethiopia. Governmental and, nongovernmental organizations, academia, and research and development-oriented partners work with NMA in the interpretation of the climate parameters produced and provide CIS to farmers. In this study the dependent variables were access to CIS and Use of CIS. Smallholder farmers' access and use of CIS is directly linked with the main CIS dissemination channels including radio, television, extension service, community workshops, and local interaction with the neighborhood. Consistency of dissemination channels in the transmission of timely information matters for the farmers' decision-making. Moreover, smallholder farmers' decision to use CIS in their farm management is linked to whether they have access or not.

Factors such as economic, demographic, institutional, farmer, and farm characteristics are the foremost determinants of access and use of climate information services among smallholder farmers in different locations (Ngigi and Muange, 2022; Muema *et al.*, 2018). Greater benefits result from rapid, accurate, and reliable access to CIS and its application in farm decision-making to enhance adaptation to climate change.

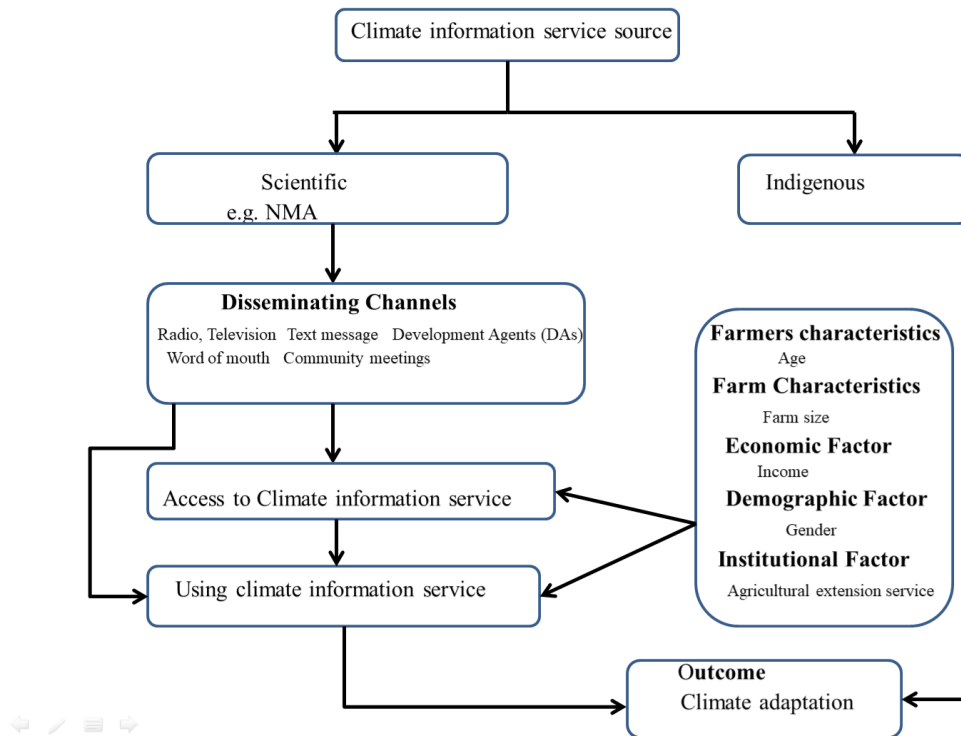


Figure 1: Conceptual framework of the methodological techniques of the study

# CHAPTER THREE

## 3. METHODOLOGY

### 3.1. Study area description

Bereh Woreda is located in the Oromia national regional state about 38 km from Addis Ababa City. Akaki and east Shewa Zones bordered southern part of the woreda, to the southwest by Addis Ababa, to the west by Sululta, to the north by the north Shewa Zone, and to the east by Aleltu. It is situated between  $8^{\circ}50'40'' - 9^{\circ}17'20''$  N; and  $38^{\circ}48'0'' - 39^{\circ}9'20''$  E covering  $844.06 \text{ km}^2$ .

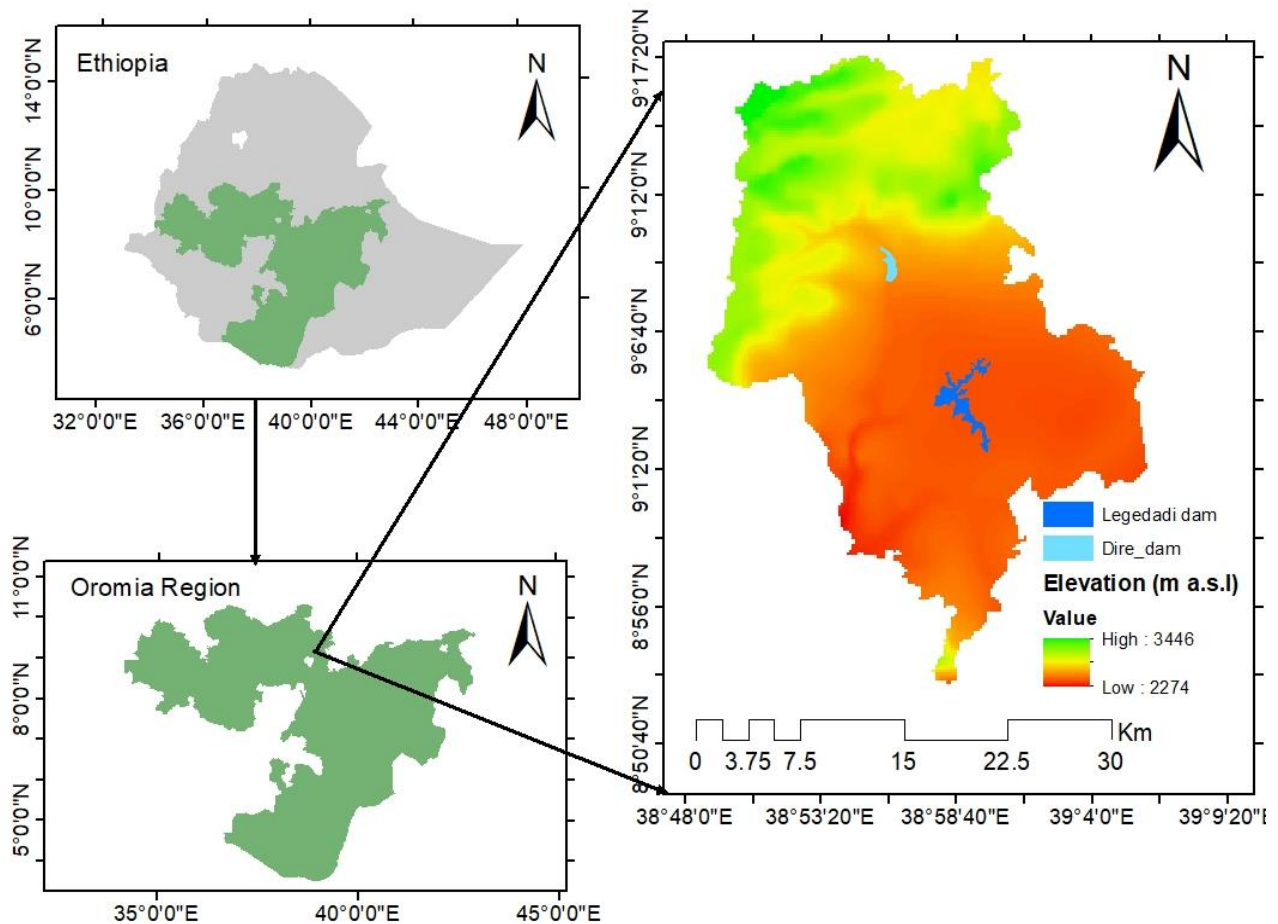


Figure 2: Location map of the study area

The woreda is characterized by two agro-climatic zones. Woina Dega accounts for 80% of the land area, and Dega for 20%, (Tolessa, 2009). Rainfall is typically in the form of localized

thunderstorms because of convective heating of the air masses during the day and rapid cooling at night. The woreda has bimodal rainfall patterns; the main rain season is between June-September and the short rain season is between March and April. The averages annual rainfall 20 years was 1111.6 mm (Figure 3).

Vertisols, Luvisols, Leptosols, Cambisols, and Fluvisols are the five major soil groups of the Woreda (AWWSA, 2011). Vertisols is the most prevalent and fertile soil type making up 65% of the soil types in flat areas and valley bottoms. Leptosols is very shallow and found in hilly to mountainous areas, accounting for approximately 12.3%. Cambisols, Luvisols, Fluvisols, and other soil types cover the remaining areas (AWWSA, 2011). Wet Vertisols are very plastic and sticky, whereas dry Vertisols are very hard (Dagar *et al.* 2016). Thus, stickiness in wet soil and hardness in dry soil make tillage difficult. Waterlogging susceptibility of Vertisols is the single most important factor reducing the actual growing period. As a result, in the study area, these soils are mostly used for extensive grazing and grasses for livestock feed.

The woreda's topography is mostly flat land with a few sloping mountains covered in a dispersed habitation pattern, making development activities more difficult. The elevation ranges from 2274 to 3446 meters above sea level. Mount Rufa (3228m.a.s.l) is the highest peak of the woreda that overlooks the town of Sendafa. Mount Yerer (3000m.a.s.l) and Mount Bereh (2700m.a.s.l) are the next high peak mountains in the woreda.

Kasem, Legedadi and Lega-tafo are the major rivers, while the Legedadi and Dire water reservoirs constructed in the study area are the critical source of water for Addis Ababa city. Chebi, Bereh, Kelate, and Haro are the major springs, and Loshe, Lege-jida, Lege-Beri, and Gewa are the known streams in the woreda (AWWSA, 2011).

The Legedadi dam was built in 1967 in the upper northwestern section of the Awash River basin about 35 km north of Addis Ababa. It has a capacity of 42.17 MCM and a yearly inflow of 87 MCM (AAWSA, 2011). The dam is located in an intensively cultivated catchment area, where rainwater runoff is the principal source of water that delivers heavy silt loads. The primary source of sediment is cultivated fields on steep and undulating slopes that lack soil and water conservation measures. The sediment not only reduces the dam's water holding capacity, but it also lowers water quality and raises the cost of water treatment.

The Dire dam, located 40 km from Addis Ababa and adjacent to the north-west of the Legedadi catchment area, was completed in 1999 and covers an area of 77.7 km<sup>2</sup>. The Dire Dam was built to meet the growing demand for water in Addis Ababa, and to boost the supply of water in the Legedadi treatment plant. The dam's capacity is 19 MCM, with an annual inflow of 50 MCM (AAWSA, 2011).

Settlement, Forest (Eucalyptus plantation), cultivated land, grazing land, bare land, built-up areas (paved road, dam, and buildings), and water bodies are the major land use types in the Woreda. Cultivated fields are the dominant land use type, however continuous and active land use land cover changes (LULC) are occurring at various spatial and temporal scales (Admasu *et al.*, 2022). According to Anteneh *et al.* (2022) the woreda has experienced significant LULC over the last three decades, which facilitates removal of soil and accelerates the deterioration of reservoir water quality and quantity. The overall rate of land change was regarded as rapid, with cultivation and settlements expanding and grazing land, bare land, and forest shrinking (Anteneh *et al.*, 2022).

Forest, woodland, shrub land, grassland, and afro-montane are the various habitat types in the woreda. *Juniperus procera* dominates the forest ecosystem, with groves of *Olea europaea cuspidata*, scattered *Hagenia abyssinica*, *Hypericum revolutum*, *H. quartinianum*, *Podocarpus falcatus*, and *Acacia abyssinica*, with *A. negrii* are disturbed in valleys, and *Erica arborea* appearing at altitudes of 3,000 m a.s.l (Fasil, 2012; Dilnesa, 2016). Previously, the area was dominated by indigenous trees such as *Juniperus procera*, *Olea europaea subsp. cuspidata*, and *Podocarpus falcatus*. However, *Eucalyptus globulus* has highly dominated the area due to overexploitation of indigenous species and introduction of exotic species for commercial purposes (EWNHS, 1996). The flora of the woreda is habitat for wild animals such as Hyenas, antelope, foxes, and gazelles.

The presence of the two major water reservoirs makes it appealing to many water birds. They are designated as important bird areas in Ethiopia because they are home to a diverse range of highland birds, particularly those found in the Afrotropical biome (EWNHS, 1996).

The woreda has 22 rural Kebeles, and a total population estimated 82,909, with a female-to-male ratio of 1:1.03 (CSA, 2007). Mixed agriculture (crop production and livestock) makes up 62% of the livelihood (Agriculture and Natural resource office of Bereh Woreda, 2023). Wheat, teff, oats

and barley are the main crops grown in the area, where as lentils, vetch, chickpeas, and horse beans are widely grown (AAWSA, 2011). Cattle and sheep are the most common bred animals followed by goats, horses, mules, donkeys, poultry, and beekeeping. The main sources of cattle feed include natural grassland, hay, crop wastes, and weeds. Aside from the region-owned stands and vegetable fields, there are also commercial eucalyptus plantations.

### **3.2. Research design**

Cross-sectional study design with a mixed methodological approach including both quantitative and qualitative methods was applied. The quantitative data was collected using a structured household survey. Whereas, the qualitative data collection was administered on focused-group discussion (FGDs) and Key informant interview (KII) as well as field observation. Accordingly, the study employed descriptive statistics and econometric model to analyze the determinants of access and use of CIS.

### **3.3. Data types and Sources**

The study has used both Primary and secondary sources of data for the analysis. Primary data was collected between March and April 2023 to obtain both qualitative and quantitative data through a structured household surveys, FGDs, and KII.

### **3.4. Sampling procedure**

The study target populations were smallholder farmers in the study area. Two-stage sampling procedure was applied to survey respondents. The first-stage used agro-ecological and expert opinion criteria. Accordingly, two Kebeles (Dibidibe Kiki and Bura Maru) that are highly exposed to climatic disasters were purposively selected. The total number of households in the two Kebeles was estimated at 813 (Agriculture and Natural resource office of Bereh Woreda, 2023). Second, systematic random sampling technique was used (Muema *et al.*, 2018; Gebru, 2014). In systematic sampling, an element of randomness is frequently introduced by utilizing random numbers to select the unit with which to begin. The study sample size was determined using Eq. 1 (Mugenda and Mugenda, 2003). This formula was used by considering a confidence level of 95% and margin errors of 0.05 (Mugenda and Mugenda, 2003).

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

Where  $n$  is sample size,  $N$  is the total number of smallholder farmers in the study area, and  $e$  is the margin of error.

Thus, Total number of households in the six Kebeles = 813

Total number of households involved in agriculture =62%

Total number of households in the six Kebeles involved in agriculture

$$(N) = 813 \times 0.62 = 504$$

$$n = \frac{504}{1+774(0.05^2)} = 219$$

### **3.5. Data collection**

A preliminary assessment was conducted in January 2023 before the actual survey was conducted to collect relevant information and understand the woreda context. A total of 219 households were surveyed between March and April 2023. The questionnaire was written in English and translated into Afan Oromo in order to obtain accurate information from the households, as Afan Oromo is native to the majority of the smallholder farmers. A total of three FGDs were consisting of six to eight participants were purposively selected with groups of different farming experience and five KII was conducted with Bereh Woreda agriculture office, NGO office, Kebele officials, and Development Agents (DAs) to obtain additional information and validate the data collected through household survey. Secondary data was obtained through a systematic review of government and institutional documents, strategies and guidelines, development policies, published and unpublished reports, websites, and online repositories of government and non-governmental organizations to verify the primary data collected (Chivaka, 2018).

### **3.6. Data Analysis**

Quantitative data were analyzed by using descriptive statistics and an econometric model employing SPSS 26 and STATA 17. Descriptive statistics were employed to generate frequencies, percentages, and means to analyze farmers' practices and perceptions of CIS. In accordance with the previous study's analysis on CIS and strategies for climate adaptation by Muema et al. (2018) and Asrat and Simane (2018), Heckman's sample selection model (heckprobit) was employed to analyze factors determining smallholder farmers' access and use of CIS.

A thematic analysis of qualitative data was applied to summarize the qualitative data collected through FGD and KII which used to justify and explain quantitative data results obtained through statistical analysis.

### 3.7. Theoretical model Estimation

The interpretation of data in this study was anchored on individual choices by adopting the random utility model (Greene, 2003). According to Greene (2003), the model considers that an individual chooses among mutually exclusive choices between t and s. Where ‘t’ represents the farmer’s choice to use CIS in farm decision making whereas ‘s’ represents the farmer’s choice not to use CIS. The study assumed that a farmer uses CIS only when the perceived utility from using CIS is significantly greater than when the farmer made a farm decision without integrating CIS. The function of a linear random utility model is given as:

$$U_{ti} = \beta_{ti}X_{ti} + \varepsilon_{ti} \text{ And } U_{si} = \beta_{si}X_{si} + \varepsilon_{si} \dots \dots \dots \text{Eq.2}$$

Following Greene (2003),  $U^t$  and  $U^s$  represent the perceived utilities; X factors are the independent variables that influence farmer’s decision to use CIS,  $\beta_t$  and  $\beta_s$  are the estimated parameters and  $\varepsilon_t$  and  $\varepsilon_s$  are the error terms assumed to be independent and normally distributed.

From the above equation observed indicator equals 1 if  $U^t > U^s$  when a farmer derived higher utility by using CIS whereas 0 if  $U^t \leq U^s$  when the farmer derived higher utility without using CIS.

Then, if we denote by  $Y = 1$  the farmer’s used CIS in their farm decision making against climatic risks. Therefore, the equation is given as:

$$\begin{aligned} \text{Prob}(Y = 1 | x) &= \text{Prob}(U^t > U^s) \\ &= \text{Prob}(\beta_{ti}X_{ti} + \varepsilon_{ti} - \beta_{si}X_{si} + \varepsilon_{si} > 0/X) \\ &= \text{Prob}(\beta_{ti}X_{ti} - \beta_{si}X_{si} + \varepsilon_{ti} - \varepsilon_{si} > 0/X) \\ &= \text{Prob}[X^*(\beta_{ti} - \beta_{si}) + \varepsilon_t - \varepsilon_s > 0/X) \\ &= \text{Prob}(X^*\beta^* + \varepsilon^* > 0/x) \dots \dots \dots \text{Eq.3} \end{aligned}$$

Therefore, this equation shows that farmer’s decision to use CIS requires more than one step. Models with two-step regressions, such as Heckman’s sample selection, are appropriate to correct for selection bias generated during the decision-making processes (Heckman, 1976).

### 3.8. Econometric Specification

Both the dependent variables; access to CIS and farmer’s decision to use CIS are dichotomous. Based on Heckman (1976), farmer’s decision to use CIS is a two-step process that can only be determined if farmers had access to CIS. In a two-step process, the second stage of CIS use is a sub-sample of the first stage access to CIS, and it is non-random and different from the first step which can create a sample selection bias (Muema *et al.*, 2018). This means that farmers with and without access to CIS may have different likelihoods of using CIS (Heckman, 1976). Therefore, a heck-probit model that is the modification of Heckman of the two-step regressions model is preferred to correct for selectivity bias (Muema *et al.*, 2018).

The selection equation of the heckprobit model analyzed determinants of access to CIS; whereas the outcome equation the model analyzed determinants of CIS use as described below in [Eq.2].

$$Y_2 = \beta X_i + \beta_\lambda \alpha_i \varepsilon_{1i} \dots \dots \dots \text{Eq.4}$$

Where  $Y_2 = 1$ , if the farmer used CIS in farm decision making and 0, Where  $Y_2 =$  use of CIS, meaningfully be observed if  $Y_1 =$  access to CIS = 1.

$$Y_1 = \alpha Z_i + \varepsilon_{i2} \dots \dots \dots \text{Eq.5}$$

$$Y_2 = \beta X_i + \varepsilon_{i1} \dots \dots \dots \text{Eq.6}$$

$$\varepsilon_1 \text{ and } \varepsilon_{2n} \sim N[0,1]$$

Where,  $\alpha$  and  $\beta$  represents the vector of coefficients associated with the independent variables,  $X_i$  and  $Z_i$  represents the independent variables that determine  $Y_2$  and  $Y_1$  respectively,  $\varepsilon_1$  and  $\varepsilon_2$  are the respective error terms normally distributed with zero mean, unit variance and correlation  $\rho$ . If  $\rho \neq 0$  the standard probit model [Eq.6] would yield biased estimates. Therefore, to correct for selectivity bias this study considered;

$$\text{Prob}(Y_1 = 1) = \text{Prob}(\varepsilon_{2i} > -\alpha Z_i) = \text{Prob}(\alpha Z_i) = \Phi(\alpha Z_i),$$

Whereby,  $\Phi$  represented the cumulative distribution at  $\alpha Z_i$ . Hence

$$E[Y_1|Y_2 = 1] = \beta X_i + \rho\sigma\lambda_i(\alpha Z_i) \dots\dots\dots\text{Eq.7}$$

Where,  $\lambda_i = \phi(\alpha Z_i)/\Phi(\alpha Z_i)$ , and probability of density function at  $(\alpha Z_i)$  is denoted by  $\phi$  (Muema, 2018).  $\lambda_i$  represents the Inverse Mills Ratio (IMR); ratio of the value of density function of standard normal distribution  $(\alpha Z_i)$  and the probability of being in the sub-sample with access to CIS, that is equivalent to the cumulative distribution valued at  $\alpha Z_i$  for the households with access and a complement of 1 for households without access (Muema, 2018). The regression coefficient on the IMR  $\beta\lambda$  is denoted by  $\rho\sigma$ . Thus, IMR from the first stage was included in the outcome equation in order to correct selectivity bias and attain unbiased estimation [Eq.2] (Muema, 2018).

In accordance with previous study by Muema (2018) farmer characteristics (Age, gender, family size, level of education, major income activity); farm characteristics (Farm size, exposure to flood and crop disease), Institutional factors, (access to extension service, and access to credit), communication assets (radio and mobile ownership) were the independent variables included in the selection equation (determinants of CIS access). These variables were similarly used in the outcome equation; however, mobile ownership was excluded from the result equation for identification purposes. According to Muema (2018) the independent variable farm characteristics; access to organic fertilizers, improved seed, herbicides, and farm equipment, were included in the outcome excluding the selection equation. This is because access to farm inputs is crucial for ensuring farmers use and benefit from CIS (Muema, 2018).

### **3.9. Statistical tests for Heckprobit model**

#### **Heteroscedasticity**

The Breusch-Pagan test was used to detect the presence of unequal variance in the regression which known as heteroscedasticity (Muema, 2018).

#### **Multicollinearity**

There are different methods suggested to detect the existence of multicollinearity problem between the model explanatory variables. Among these methods, variance inflating factor (VIF) technique was employed to detect multicollinearity problem among the explanatory variables.

## Correlation Matrix

This method was employed to detect the degree of association among the explanatory variables.

## Endogeneity Test

Hausman test was employed to test for endogeneity where the expected endogenous variables regressed against with the exogenous variables (Muema, 2018).

### 3.10. Justification of Variables of the model

#### Dependent Variable

The dependent variables selected to be used for the binary logit regression model are namely access to climate information service and use of climate information services.

- **Determinants of access to CIS:** this means there is different dissemination channels by which the climate information service is being delivered and the ability of the farmers to get climate information will be affected by their access to the available instruments.
- **Determinants of CIS use:** the availability and access to climate information service does not guaranty farmers use or application of climate information in farm decision making.

#### Explanatory Variables

Table 1 below shows the expected correlation of the independent variables that determine the access and use of the climate information services among smallholder farmers to be used in the heckprobit model.

Table 1: The summary statistics for independent variables

Variable description	Nature of variable	Expected correlation in access to CIS	Expected correlation in use of CIS
Age of HH	Continuous	-	-
HH Education level	Continuous	+	+
Gender of HH	Dummy (Male=1 Female=2)	+	+
Household size	Continuous	+	+

Farm size	Continuous	+	+
Major source of income	Dummy (Farming=1 Other=0)	+	+
Access to extension service	Dummy (Yes=1 No=0)	+	+
Access to radio	Dummy (Yes=1 No=0)	+	+
Access to mobile	Dummy (Yes=1 No=0)	+	+
Access to credit	Dummy (Yes=1 No=0)	+	+
Access to farm inputs	Dummy (Yes=1 No=0)	*	+

**NB: The \* in the table shows that the variables will not be included in the equation.**

**Age:** this variable is continuous and predicted to have an inverse connection with both the availability and use of CIS. The table above implies that it has a correlation with the amount of experience in farming and is expected to reduce the odds of using, and having access to, CIS. Hence, as per Oyekale (2012), since veteran farmers often have set approaches to dealing with climate associated risks, they lean towards using the traditional ways rather than scientifically backed methods.

**Education level:** is expected to show a positive sign as the level of education of the smallholder farmers increased their access and use of climate information services and the probability of accepting new technology of better agricultural services also increases.

**Gender:** - men and women are expected to have different likelihoods to access of CIS from different dissemination channels depending on their day-today activities and asset ownership.

**Household size:** - this is expected to show positive association, because increasing in the number of household member increases to the level of interest and demand for climate information services (Young, 2014). On the other hand, additional productive household member might seek off-farm employment than depending on farm income which reduces access and use of climate information service, and this could reduce the likelihood of increase in access and use of climate information services (Oyekale, 2012).

**Farm size:** because land is an important factor in coping and adapting to climate change, households with large farm sizes are expected to have a higher likelihood of accessing and using

climate information services. This is because farmers with large farms can practice crop and livestock diversification and spread climate-related risks (Young, 2014; Belay *et al.*, 2017).

**Access to extension services:** - this is a formal service that has a significant impact on increasing farmers' access and use climate information services. Moreover, access to extension agents grants opportunities for farmers to gain more climate information, advisory services, and training.

**Ownership of radio/ television/mobile phone:** Households' access and use of CIS is anticipated to increase with their get entry to communication property. This is due to most CIS vendors disseminate records via those conversation belongings. For example, majority of farmers in Ethiopia decide upon radio as the main dissemination channel (Seneshaw *et al.*, 2022).

**Major income activity:** farmers taking farm activity as a sole income are expected to have better access and use of climate information service (Oyekale, 2012).

**Access to farm inputs:** access to climate information alone will not have effect on farmers' decision, but it is dependent on the availability of input resource (Muema *et al.*, 2018).

### **3.10. Ethical Consideration**

This study strictly adhered to ethical standards and maintained a high level of professionalism by national and international ethical procedures. The proposal of the study was evaluated and approved by Institutional Review Board (IRB) and the academic commission organized by the Center for Environment and Development Studies for further progress. A support letter written by the Center was presented to Bereh Woreda Agriculture Office. Enumerators was trained before beginning the data collection to inform each respondent about the purpose of the study and the confidentiality of their personal information, as well as to ask for and respect participants' willingness to share information through questionnaires, interviews, and discussions. Confidentiality was maintained by using codes rather than respondents' names, which could lead to the individual's identification. The study's confidentiality was prioritized in all aspects.

# CHAPTER FOUR

## 4. RESULTS AND DISCUSSION

### 4.1. Socio-economic characteristics

The descriptive statistics of the respondents is presented in Table 2 below. The results showed that survey respondents were dominated by males, comprising 81.3% of the total respondent. Several factors such as economic condition of households led by women, as well as the lack of information and cultural factors might be the reasons behind this finding. Respondent's age ranges between 18 and 78 years with a mean ( $\pm$ SD) of 40.5 ( $\pm$ 13.3) years old. The mean ( $\pm$ SD) respondents farm experience was 24.34 ( $\pm$ 13.18) years, which imply that the respondents have adequate farming experience.

Table 2: Descriptive analysis of sample households

Variables	Mean	Standard deviation
Age	40.5	13.3
Gender (male %)	81.3	
Family size (number)	5.4	2.02
Education level (%)		
• Illiterate (%)	43.8	
• Primary education (%)	50.7	
• High school and above (%)	5.5	
Farm size (ha)	1.65	0.88
Mixed farming as major income activity (% yes)	77.2	
Availability of climate information (% Yes)	90.9	
Availability of extension service (% Yes)	85.4	
Access to extension service (% Yes)	43.8	
Ownership of radio (% Yes)	96.3	
Ownership of mobile (% Yes)	54.3	
Access to credit (% Yes)	39.3	

Farming experience (Years)	24.34	13.18
Access to herbicides (% Yes)	37	
Access to organic fertilizer (% Yes)	56.2	

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Mean ( $\pm$ SD) of respondents family size was 5.4 ( $\pm$ 2.02). 63% of the total households have more than five family members. This finding is slightly above the national average family size of five (ILA, 2021). The mean ( $\pm$ SD) land size of respondents was 1.65 ( $\pm$ 0.88) ha, which is higher than the national average farm size of 0.73 ha per household in rural households (CSA, 2021).

The education level of survey respondents was categorized into three categories: namely, illiterate, primary education and secondary and above. The result revealed that nearly half (50.7%) of the respondents completed primary school, while 43.8% were illiterate and the remaining 5.5% completed high school and above level. It is well known that, education have an impact on a family's socioeconomic status and technology adoption. Thus, the study communities have potential to adopt CIS as considerably large proportion (56.2%) is literate (Oyekale, 2015; Muema *et al.*, 2018).

The survey revealed that 39.3% of the smallholder farmers participated in the survey had access to credit services; however, lack of collateral, lengthy procedure and high interest rate are the prime constraints to access financial service. In connection to this Zerssa *et al.*, (2021) reported that access to credit and utilization of the service is crucial for smallholder farmers in climate adaptation.

The survey showed that the majority (96.3%) proportion of the survey households own radio and 54.3% own mobile phones. About 37% and 56.2% of the respondents have access to basic farm inputs such as herbicides and organic fertilizer mainly compost, respectively which are important to increase agricultural production and thereby adapt climate change impact. Despite, smallholder farmers have access to organic fertilizers mainly compost and herbicides, the higher price of the inputs has been hampering the proper use of CIS in farm decision making. Mamo, (2009) reported that farmers in Bereh woreda are unable to afford rising farm input prices as they have low income. Like most Ethiopian rural areas 77.2% of the respondents' livelihood based on mixed farming system where they practice both crop and livestock production (Table 2).

## 4.2. Smallholder Farmer’s Practice to Climate Information Services

Smallholder farmers have been vulnerable to several climate shocks (Figure 3). All respondents indicated the presence of frost. In addition, 48.4%, 87.2%, and 91.3% of respondents identified the presence of recurrent floods, occurrence of crop disease, and erratic rainfall, respectively. The study area is among the highlands of the country characterized by climatologically sensitive ecosystems (AAWSA, 2011). As confirmed by FGDs and KIIs, the effects of climate change on the environment is visible. The qualitative data (FGDs and KIIs) revealed that major climate change and variability indicators indicated have greatly impeded livestock and crop production. FGDs and KIIs verified that strong frost, occurrence of herbicide-resistant crop disease such as; Faba bean rust (*Uromyces viciae-fabae*) and wheat rusts (*basidiomycete Puccinia graminis f.sp. triticina*), frequent occurrence of very high intensity rainfall which exacerbating sever soil erosion, and drying up of springs are among the major climate change induced hazards experienced over the last two decades.

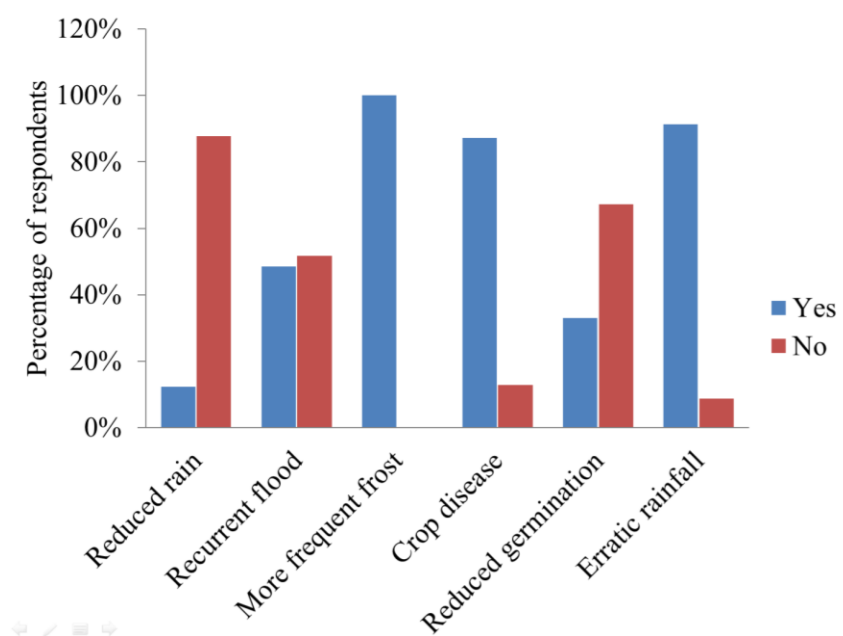


Figure 3: Climate variability indicators identified by households

Smallholder farmers in the study area obtain CIS from indigenous and scientific forecasts. 68.5% of the respondents take both indigenous and scientific forecasts as their source of CIS. The remaining 22.4% smallholder farmers take only scientific forecasts while 9.1% take indigenous forecasts as their source of CIS (Figure 4). Indicators for indigenous weather forecasting include

observing soil fertility status, observing the moon, clouds in Mount Yerer, and listening to the sounds of frogs. The study by Muema (2018) reported that the several indicators of indigenous climate forecast in Kenya include motions of the moon and stars, behavioral variation and arrival of insects and birds, and trees blossoming In Tanzania few of the indigenous forecast indicators for weather prediction includes iridescence of cloud changes and intestine color of butchered animal (Coulibaly et al., 2015). This show that indigenous forecast indicators are location specific due to culture and belief of the community.

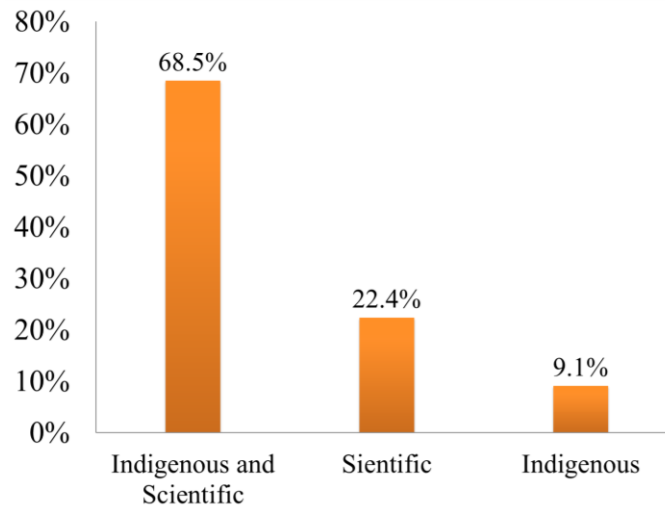


Figure 4 : Source of CIS

The analysis of forecast services revealed that smallholder farmers accessed multiple types of weather forecasts with and without agricultural advisory services (Table 3). Hence, 66.7%, 26.5% and 19.6% of the respondents had only the access to seasonal, decadal and daily forecast without additional agricultural advisory services, respectively. Of the total smallholder farmers in the survey 175 (79.9%) reported that they had the access to climate information accompanied with agricultural advisory services. Of these, about 49% of households use the CIS in their farm decision-making. This finding is consistent with Oyekale (2015) who reported that only few of those who have access to weather and climatic information used it for farm decision making. Furthermore, about 77.6% of the respondents accessed decadal forecasts followed by seasonal forecasts and monthly forecasts, 67.3% and 2.3% respectively (Table 3). The KIIs also verified that decadal forecast is the most frequently provided forecast type to farmers accompanied with agricultural advisory services. The various agricultural advisory services influenced by CIS

included changes in planting schedule, the timing of land preparation, crop type, crop variety, and harvesting schedule. These finding is similar with Asrat and Simane (2018); Antwi-Agyei *et al.* (2021); Muema *et al.* (2018) and Serra and Mckune (2016) research results who reported that adjusting planting, harvesting schedules, use of climate smart crop varieties, different improved agronomic practices like crop rotation, and intercropping are the various farm decisions inclined by CIS.

Table 3: Types of weather forecast frequently accessed by smallholder farmers

Types of forecasts	Access to climate information%	With agricultural advisory services%
Seasonal	66.7	67.3
Decadal	26.5	77.6
Daily	19.6	*
Monthly	3.7	2.3
Access to CIS	79.9%	
Farm decision maker	49.15%	

**NB: The \* Daily agronomy service not available**

The smallholder farmers participated in the household survey and FGDs indicated that they have a multiple channels for climate information (Table 4). Of the total respondents, 96.3% of the respondents accessed climate information predominantly through radio followed by extension service of the agriculture office (43.8%) and word of mouth (18.3%). The information received through television and community meetings contributing only 2.7% each; as source of climate information to smallholder farmers. Radio is the most effective and cost-efficient CIS dissemination channel preferred by majority of the respondents. Similarly Oyekale (2015) reported that radio is often chosen as means of disseminating information to local farmers due to its broad coverage. Even though 85.4% of the respondents perceived the availability of agricultural extension services (Table 2), less than half of them accessed CIS from agricultural extension service providers (DAs). The limited coverage of CIS in extension services indicates that farmers' climate adaptation capacity is highly hindered in the study area. This finding is concurrent with Muema *et al.* (2018) and Ochieng *et al.* (2017) who reported that regardless of

being important and trusted source, majority of smallholder farmers lack access to extension services in SSA.

Table 4: Summary of climate information dissemination channels

climate information dissemination channel	Accessed (%)
Radio	96.3
Extension service	43.8
Television	2.7
Word of mouth	12.8
Community meetings	2.7

The smallholder farmers have perceived the importance of CIS at different level of extent. About 70.8% of the respondents have perceived CIS moderately important; whereas, 27.9% and 1.4% have high and low levels of perception, respectively (Figure 5).

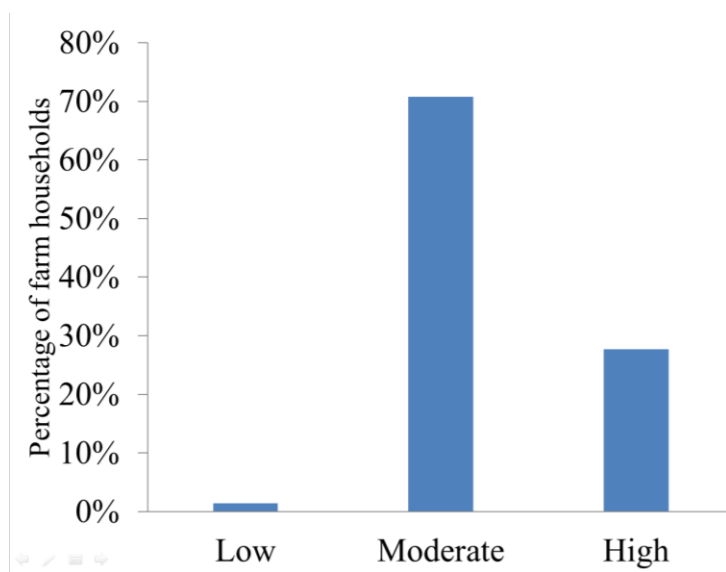


Figure 5: Households level of extent perceived CIS important

### 4.3. Determinants of smallholder farmers access to Climate Information Services

Factors determining CIS access among smallholder farmers are interpreted with the marginal effects of the parameters in the results. The test for multicollinearity revealed that the independent variables are not correlated thus all variables are included in the model estimation. The Hausman test revealed that there was no endogeneity. The statistical significance of the log-likelihood indicated that the Heckprobit model's result fit the data well, which was significant at 1% (Wald Chi-square = 44.26, p-value 0.001), indicating a high explanatory power.

Results of the selection model for the access to CIS (Table 5) indicate that age of the household head ( $P < 0.01$ ) and off-farm income ( $P < 0.05$ ) significantly reduced the likelihood of smallholder farmers' access to CIS while mobile ownership ( $P < 0.1$ ) and gender of the household ( $P < 0.01$ ) increased the likelihood of accessing CIS. A one-year increase in the age of the household head reduced the likelihood of accessing CIS by 0.7%. This indicates that older farmers have less likelihood of accessing CIS, which is a crucial element that is tied to agricultural experience (Muema *et al.*, 2018). This result is concurrent with the findings of Yong (2014), Kirui *et al.* (2014), Onyeneke *et al.* (2023), and Muema *et al.* (2018), proving that older farmers have improved their climate observation and risk dissemination skills indigenously that results in lower demand for CIS. Even though older household heads manage several adaptation strategies in the active workforce, young household heads apply various climate adaptation techniques more frequently than older household heads (Megabia *et al.*, 2022). Smallholder farmers' likelihood of accessing CIS is decreased by 8.4% per unit rise in those who derive majority of their income from off-farm sources. This may be explained by the fact that farmers who also generate income from non-agricultural sources do not properly follow up on agriculture, which reduces their desire for and motivation to access CIS. This finding is consistent with the findings of Asrat and Simane (2018), which show that households engaged in non-farm activities are less reliant on crop farming and thus less inclined to invest in climate adaptation (Table 5).

An increase in household's ownership to mobile phones enhances the odds of access to CIS by 11.1%. Mobile phones are one of the sources through which farmer's access information that promotes their productivity and enhances climate resilience. This finding concurs with that of

Onyeneke *et al.* (2023) who established that an increase in farmer's mobile phone ownership resulted in influencing their access to CIS.

Gender of the households has increased the likelihood of accessing CIS. This finding indicates that male-headed households have more likelihood of accessing CIS than female-headed households. This result is consistent with a previous study by Deressa, *et al.* (2008) who reported that male-headed households have better readiness to climate change adaptation.

Table 5: Results of the Heckprobit model selection equation for smallholder farmers CIS access

Access to CIS						
Regression				Marginal effect		
Independent variables	Coefficient	Std. Err	P value	dy/dx	Std. Err	P value
Age of HH	-0.028	0.011	0.012***	-0.007	0.0027	0.01***
Household size	0.025	0.055	0.645	0.0065	0.014	0.645
Farm size	0.11	0.132	0.394	0.029	0.033	0.391
Education level	-0.013	0.238	0.958	-0.003	0.061	0.958
Mobile ownership	0.515	0.388	0.185*	0.111	0.069	0.107*
Radio ownership	0.469	0.511	0.359	0.143	0.178	0.424
Credit access	-0.008	0.213	0.970	-0.002	0.054	0.97
Access to extension service	-0.169	0.219	0.438	-0.044	0.057	0.44
Gender of HH	0.842	0.285	0.003***	0.262	0.098	0.008***
Source of income	-0.349	0.151	0.021**	-0.089	0.038	0.021**
Crop disease	-0.321	0.334	0.336	-0.073	0.066	0.271

*Notes:* \*\*\*, \*\*, \* significance levels at 1%, 5%, and 10%, respectively. Number of obs 219, Censored obs 175, Uncensored obs 44, Log likelihood = -169 Wald chi2 (14) = 44.26 Prob > chi2 0.0001. LR test of indep. eqns. (rho = 0): chi2 (1) = 3.54 Prob > chi2 = 0.0599.

#### 4.4. Determinants of smallholder farmers Climate Information Services use

Factors determining CIS use among smallholder farmers are interpreted with the marginal effects of the parameters in the results (Table 6). The test for multicollinearity revealed that the independent variables are not correlated thus all variables are included in the model estimation. The outcome model result for smallholder farmer's use of CIS indicate that age of the household head, total farmland, and gender of the household head significantly reduced the likelihood of using CIS ( $P < 0.01$ ). Radio ownership and access to herbicides increased the likelihood of using CIS ( $P < 0.1$ ). Likewise, farming as a major income is statistically significant ( $P < 0.05$ ) in

enhancing smallholder farmer's likelihood of using CIS. An increase of one year in the age of household head decreases smallholder farmers' likelihood of using CIS by 1.5%. This implies that younger households applied CIS in their farm decision-making more than older households. This is expected since younger farmers are more experimental and dynamic and may try practices and technologies that would boost their adaptive and buffer capacities (Onyeneke, 2021). This finding is consistent with Muema *et al.* (2018) and Onyeneke *et al.* (2023) who proved that increase in the age of the household head reduced the likelihood of utilizing CIS.

With a unit increase in the farm size of the household, the likelihood of using CIS reduces by 21.1%. This result is concurrent with the findings of Mwinkom *et al.* (2021). Contrarily, Gebru (2014) reported that increased use in a unit of farm size enhanced farmers' use of climate adaptation strategies.

The result showed that the gender of household head reduced the likelihood of using CIS. This indicates that female-headed households had less likelihood of using CIS compared to male-headed households. This result is concurrent with the findings of Aryal *et al.* (2022) who reported that women's workload in domestic tasks greatly affects their likelihood of using climate change adaption measures. Furthermore, Zeray and Demie (2015) reported that male-headed households are more likely to utilize climate adaptation techniques, raising the question of whether climate adaptation strategies are gender specific and can be interpreted as an indicator that climate adaptation strategies may be more labor intensive and access to information.

The likelihood of using CIS increases by 12% for each additional unit of household head access to herbicides. Similar findings were reported by O'Brien *et al.* (2000); Patt *et al.* (2005) and Muema (2018) that farmers' capacity to use CIS in farm decision-making was reliant on access to essential farm inputs.

Table 6: Result of the Heckprobit model outcome equation for smallholder farmer's CIS use

Use of CIS						
Independent variables	Regression			Marginal effect		
	Coefficient	Std. Err.	P-value	dy/dx	Std. Err	P-value
Age of HH	-0.044	0.011	0.000***	-0.015	0.004	0.000***
Household size	-0.011	0.058	0.853	- 0.004	0.019	0.853
Farm size	-0.637	0.169	0.000***	-0.211	0.058	0.000***
Education level	0.189	0.202	0.349	0.063	0.067	0.349
Access to improved seed	0.199	0.268	0.459	0.064	0.084	0.445
Access to organic fertilizer	0.011	0.215	0.958	0.004	0.072	0.958
Radio ownership	1.145	0.717	0.11*	0.432	0.252	0.086*
Credit access	0.174	0.236	0.462	0.056	0.077	0.457
Extension service	-0.1002	0.219	0.648	-0.033	0.073	0.649
Access to herbicides	0.389	0.246	0.114*	0.125	0.076	0.1*
Gender of HH	-0.982	0.375	0.009***	-0.256	0.069	0.000***
Access to farm equipment	-0.062	0.429	0.886	-0.02	0.138	0.884
Source of income	0.332	0.168	0.048**	0.11	0.055	0.044**
Crop disease	0.365	0.306	0.233	0.129	0.114	0.257

A unit increase in household ownership of radio enhances the likelihood of using CIS by 43.2%. This is because radio was the preferred channel for disseminating CIS in the study area. In addition, radio broadcasts disseminate information in vernacular languages and are the most

cost-effective and efficient way to enhance the use of climate information by all farmers. This finding is consistent with Onyeneke et al. (2023) and Muema et al. (2018) who found that ownership of radio likely enhances farmers' use of CIS, because local languages are used to disseminate climate information making it credible and preferable.

Likewise, likelihood of using CIS is enhanced by 11% as majority of household heads income from farming increases by one unit (Table 6). This result is supported by Deressa *et al.* (2008) research report who found that farmers tend to invest in climate adaptation options which compete with the limited land available when farming is the primary source of income.

# CHAPTER FIVE

## 5. CONCLUSION AND RECOMMENDATIONS

### 5.1. Conclusion

The study has provided valuable insights on determinant factors of smallholder farmer's access and use of CIS in Bereh Woreda. The various climate change and variability indicators perceived by smallholder farmers were frequent frost, occurrence of frequent crop diseases, erratic (heavy) rainfall, and frequent flood. Despite smallholder farmers considerably access CIS, few of them are still solely relied on indigenous practices. Majority of smallholder farmers perceived CIS as moderately important in order to integrate in their day-to-day farm decision making. More than half of the respondents had access to climate information accompanied with agronomic advice. However, less than half of the total respondents who have access to CIS are using the information in their farm decision-making.

The primary dissemination channel of CIS was radio, followed by agricultural extension services. Older farmers are less likely to access and use CIS than young farmers. Providing information that is compatible with the needs of older farmers and targeting young farmers in formulation and dissemination to enhance the access and use of CIS among all age groups is very crucial.

The gender of the household head has a greater influence on access and use of CIS. Male-headed households dominated the likelihood of accessing CIS, whereas female-headed households are less likely to use CIS. This indicates the vulnerability of female-headed households is very higher to different climatic disasters. Mobile ownership increases the likelihood of accessing CIS, whereas income from off-farm activities reduced the likelihood of accessing CIS. Radio ownership, access to herbicides, and mixed farming as a major livelihood enhanced the likelihood of using CIS. Moreover, a unit increase in farm size reduced the likelihood of using CIS.

## **5.2. Recommendation**

The National Meteorology Agency, Agro-met task force groups, and other providers of CIS shall give emphasis on addressing these issues by providing accurate, timely, and usable information. In order to increase smallholder farmers access and use of scientific weather information. CIS providers should also take into account enhancing the quality of modern CIS together with the indigenous weather forecast practice.

The likelihood of accessing CIS increased with mobile ownership, while the likelihood of using CIS increased with radio ownership. To ensure that most farmers can access and use CIS, providers should improve the timely and regular broadcast of precise climate information. Moreover, CIS disseminated through broadcasts should be accessible with the local language in order to enhance access to very clear and usable information. To make CIS utilized by smallholder farmers, CIS providers should pay the highest attention and guidance intended information in terms of training for all age groups especially targeting young smallholder farmers since they had a higher likelihood of accessing and using CIS as well as intensive awareness should be created for the older smallholder farmers. Female-headed households have less likelihood of accessing and using CIS than male-headed households. Therefore, providers should empower female-headed households to improve their access and use of CIS with better production resources and improved information distribution through favorable channels.

Households' access to herbicides increased the utilization of CIS. Resources should be made available to ensure the access to herbicides by all farmers at a reasonable price in order to improve farmers' ability to adapt to climate change and enhance their agricultural productivity.

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## APPENDICES

### I Household questionnaires

#### Addis Ababa University

#### Title of the research topic: Determinants of Farmer's access and utilization of climate and information services; the cases of Bereh Woreda, Oromia Region, Ethiopia

Dear Respondent,

My name is Tsion Fikadu, MA student in Development studies (Environmental and sustainable development) at Addis Ababa University. I am undertaking a research on "Determinants of Farmer's access and utilization of climate and information services; the cases of Bereh Woreda, Oromia Region, Ethiopia". The purpose of this survey is to interview the head of household, spouse and the older family member over the age of 18 who is responsible for household farm decision making. Your response will be greatly appreciated, and please be assured that any information including your name will not be part of any report from this evaluation and will be strictly kept confidential. Therefore, you are encouraged to answer as many questions as possible but you can fully or partly quit the interview or ask questions at any time as the participation is fully voluntary.

A00: The interview will take about 45 minutes, thus do you have any question and are you willing to take part in the discussion?            **Yes = 1**    **No = 0**

For further information kindly contact Tsion Fikadu via mobile 0935341167. I kindly request we start the interview.

#### Section I: Household background information

1 Name of respondent \_\_\_\_\_ and Code of the respondent \_\_\_\_\_

2 Name of Kebele \_\_\_\_\_

3 Phone number \_\_\_\_\_

4 Household head gender:

A) Male

B) Female

5. Marital status

A. Married

B. Single

C. Divorced

D. Widow/ Widower

6. Age of the household head \_\_\_\_\_

7. What is the highest level of formal education completed by the household head?

A. Illiterate

B. Primary school

C. Secondary school and above

8. How many people live in your household? \_\_\_\_\_

9. What is your source of income?

A. Agriculture (crop & livestock production) only

B. Employed

C. Business

D. Agriculture and business

E. Other \_\_\_\_\_

10. How many years of farming experience do you have? \_\_\_\_\_

11. What is the size of your farm? \_\_\_\_\_

## **Section II: Practice and attitude towards climate information service**

1. To what extent do you agree with the statements below on climate change over the past 10 to 20 years (**Multiple answers possible**)?

- A. The number of rainy days has reduced
- B. Occurrence of frequent floods
- C. Occurrence of frequent frost/drought
- D. New crop disease have emerged
- E. Increased failure rate of germination
- F. No change/I have difficulty to judge

2. To which of the following climate shocks have you been exposed? (**Multiple answers possible**)

- A. Flood
- B. Frost/Drought
- C. Erratic rainfall
- D. Landslide

3. Have you heard of climate and weather forecasts?

- A. Yes
- B. No

4. Which of the following is your source of climate weather forecast?

- A. Scientific forecasts
- B. Indigenous forecasts

5. At what extent do you perceive the importance of climate information in your farming activities?

- A. Not at all
- B. Small extent
- C. Medium extent
- D. Very Large extent

6. If the answer for Q5 is important, how useful do you find the climate information services?

- A. Very useful
- B. Somewhat useful
- C. Not very useful
- D. Not at all

7. Do you have trust for the information you receive from scientific climate forecasts?

- A. Yes
- B. No

8. If “Yes”, to what extent do you trust the information received?

- A. small extent
- B. medium extent
- C. large extent
- D. very large extent

9. If “No”, which one is your reason?

- A. Not accurate
- B. I am not familiar with the forecast
- C. Complicated to understand
- E. other \_\_\_\_\_



A. Inorganic fertilizers seeds  
B. Organic fertilizers  
C. Improved seeds

D. Pesticides  
E. Herbicides  
F. Farm equipment  
G. Other

7. Do you have access to credit facilities?

A. Yes  
B. No

8. If “Yes”, which of the following is your source of credit services?

A. Cooperative bank  
B. Agriculture finance cooperative  
C. Community based organization  
D. Other.....

9. If “No”, which of the following is the reason that barred you from access to credit? **(Multiple answers possible)**

A. Lack of Collateral  
B. High interest rate  
C. lengthy procedures  
D. Unable to pay back  
E. Other.....

10. Is there any factor that prevents you from accessing climate information services?

A) Yes  
B) No

11. If “Yes” to question 10, which of the following factors prevent you from accessing climate information services? **(Multiple answers possible)**

A. Lack of awareness  
B. Lack of access to radio/mobile  
C. Other\_\_\_\_\_

**Section IV: Utilization of climate information service**

1. If you receive climate information do you use it for farm decision making?



- A) Changes in the timing of land preparation
- B) Changes in the timing of harvesting
- C) Type of crop variety to grow (use of early maturing/frost tolerant crop)
- D) Changes in timing of fertilizer application
- E) Other \_\_\_\_\_

7. What type of support would you need to better access and use climate information services?

- A. Training should be given
- B. Provision of internet access
- C. Reduction of costs for accessing the service
- D. Other \_\_\_\_\_

## II. FGD and KII transcription template

### FGD transcription table

	Question	Response			
		Kebele 1	Kebele 2	Kebele 3	Summary
<b>1</b>	<b>Climate change and its impacts</b>				
1.1	What are the climate change impacts you have observed in the last 10-20 year				
1.2	How does it affect your agriculture?				
<b>2</b>	<b>General attitudes and practice about CIS</b>				
2.1	What is your previous experience with access and use of CIS?				
2.2	What are the indicators mostly used for indigenous weather forecast?				
2.3	Does the scientific CIS satisfy your needs?				
<b>3</b>	<b>Access and use of CIS</b>				
3.1	From which sources do you get climate information?				
3.2	Does the climate information				

	you receive from extension services combined with advice?				
<b>3.3</b>	Do you made any change in your farming practices due to the information? If so what changes have you observed in your farming after using the received information?				
<b>4</b>	<b>Factors affecting access and use of CIS</b>				
<b>4.1</b>	What are the factors that are affecting your access to CIS?				
<b>4.2</b>	What are the factors that challenge you from using CIS in your farming decisions?				
<b>4.3</b>	What solutions do you suggest to address the challenges in access and use of CIS?				

### **KII transcription table**

	<b>Question</b>	<b>Response</b>			
<b>1</b>	<b>Climate change and its impacts</b>				
<b>1.1</b>	What are the climatic hazards that frequently affect the woreda? And level of climate variability in the woreda?				
<b>1.2</b>	How do impacts of climate change affect the agriculture sector?				
<b>1.3</b>	What are the common adaptation mechanisms the woreda promote to the farmers to cope up with the impacts and for preparedness?				
<b>2</b>	<b>Practice of CIS</b>				
<b>2.1</b>	How long have it been since your organization started providing CIS to the smallholder farmers?				
<b>2.2</b>	How many farmers are accessing CIS and how many of them are using CIS in their farm decision making continuously?				

<b>3</b>	<b>Access and use of CIS</b>				
3.1	What are the common CIS dissemination channels in the woreda?				
3.2	What type of weather forecasts are frequently provided to the smallholder farmers?				
3.3	Is the information provided by CIS providers largely comprehensible to the smallholder farmers?				
3.4	What are the implications of improved access and use of CIS among smallholder farmers and how are these implications being measured and evaluated?				
3.5	How are various organizations collaborating to improve farmers' access to and use of CIS?				
3.6	What are the agricultural inputs provided to the farmers in order to support their CIS use in their farming decisions? And are these inputs affordable to the farmers?				
3.7	What challenges has the woreda faced in providing CIS to smallholder farmers?				
3.8	What measures are being taken as a solution for the challenges?				

## II. Analysis of Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) HH Age	1.000											
(2) Family size	0.177	1.000										
(3) Farm size	0.009	-0.009	1.000									
(4) Education level	-0.350	-0.048	-0.127	1.000								
(5) Access to improved seed	-0.011	-0.002	-0.013	-0.076	1.000							
(6) Access to organic fertilizer	0.184	-0.016	-0.053	-0.117	0.053	1.000						
(7) Mobile ownership	-0.466	-0.056	0.051	-0.132	0.100	0.002	1.000					
(8) Radio ownership	-0.077	-0.000	0.013	0.107	0.070	0.073	-0.100	1.000				
(9) Access to credit service	0.094	0.001	-0.076	-0.029	-0.077	-0.081	-0.057	-0.043	1.000			
(10) Access to extension service	-0.079	0.121	0.103	-0.052	0.008	-0.036	0.046	-0.122	-0.051	1.000		
(11) Access to herbicides	0.111	0.000	0.103	-0.121	0.391	-0.048	0.088	-0.153	-0.035	-0.010	1.000	
(12) Gender of HH	0.096	-0.098	-0.153	0.148	0.046	0.001	-0.174	0.094	-0.070	-0.001	0.004	1.000
(13) Access to farm equipment	-0.214	-0.005	-0.058	0.160	-0.289	-0.152	-0.018	-0.062	0.125	-0.007	-0.217	-0.071
(14) Major income source	-0.169	-0.174	-0.072	0.013	-0.033	-0.076	0.112	-0.086	0.016	-0.101	0.090	0.144
(15) Crop disease	-0.031	-0.032	0.078	0.107	-0.180	0.020	0.071	-0.075	-0.056	0.008	-0.103	-0.044

	(13)	(14)	(15)
Access to farm equipment	1.000		
Major income	0.012	1.000	
Crop disease	0.068	-0.05	1.000

## IV. Multicollinearity test

### Variance inflation factor (access to CIS)

	VIF	1/VIF
Age of HH	1.823	.549
Mobile ownership	1.517	.659
Education level	1.402	.713
Gender of HH	1.15	.87
Major income source	1.124	.89
Family size	1.091	.916
Access to extension service	1.085	.922
Radio ownership	1.084	.922
Farm size	1.067	.937
Crop disease	1.048	.954
Access to credit service	1.031	.97
Mean VIF	1.22	.

**Variance inflation factor (CIS use)**

	VIF	1/VIF
Age of HH	1.41	.709
Access to improved seed	1.329	.753
Access to herbicides	1.31	.763
Education level	1.261	.793
Access to farm equipment	1.213	.824
Gender of HH	1.151	.869
Major income source	1.144	.874
Radio ownership	1.121	.892
Family size	1.094	.914
Farm size	1.094	.914
Access to organic fertilizer	1.092	.916
Access to extension service	1.085	.922
Crop disease	1.074	.931
Access to credit service	1.063	.941
Mean VIF	1.174	.

V. Chi2 test results

Access to CIS	Female	Male	Total	Pearson chi <sup>2</sup>	P-value
No	13	31	44	4.23	0.03
Yes	28	147	175		
Total	41	178	219		

CIS Use	Female	Male	Total	Pearson chi <sup>2</sup>	P-value
No	22	86	108	0.38	0.53
Yes	19	92	111		
Total	41	178	219		

Access to CIS	Farming	Off-farm	Total	Pearson chi <sup>2</sup>	P-value
No	105	33	138	2.09	0.35
Yes	64	17	81		
Total	169	50	219		

CIS Use	Farming	Off-farm	Total	Pearson chi <sup>2</sup>	P-value
No	82	29	111	1.79	0.4
Yes	87	21	108		
Total	169	50	219		

## VI. Endogeneity Results

Using CIS	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age	-.018	.003	-7.01	0	-.023	-.013	***
Household size	.004	.015	0.29	.772	-.025	.034	
Total_farm_land	-.099	.035	-2.86	.005	-.167	-.031	***
Education level	.048	.055	0.88	.378	-.059	.156	
Access to improved seed	.088	.074	1.19	.236	-.058	.234	
Access to organic fertilizer	-.027	.061	-0.45	.656	-.148	.093	
Ownership of radio	.142	.164	0.86	.388	-.182	.465	
Credit facilities extension service	.012	.061	0.19	.847	-.109	.133	
Access to herbicides	-.095	.061	-1.56	.121	-.215	.025	
Gender	.061	.069	0.89	.376	-.075	.197	
Access to farm equipment	-.044	.08	-0.55	.584	-.201	.114	
Access to farm equipment	-.008	.111	-0.07	.944	-.227	.211	
Major income source	-.006	.043	-0.14	.892	-.09	.078	
Higher crop disease	.06	.09	0.66	.509	-.118	.238	
Constant	1.116	.323	3.46	.001	.48	1.753	***
Mean dependent var		0.493	SD dependent var			0.501	
R-squared		0.310	Number of obs			219	
F-test		6.561	Prob > F			0.000	

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$