UNIVERSITY OF NAIROBI

ENHANCING SMALLHOLDER FARMERS' RESILIENCE THROUGH EFFECTIVE CLIMATE COMMUNICATION CHANNELS IN RWANDA: A CASE STUDY OF RUHANGO DISTRICT

By

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DECLARATION STATEMENT

This research is my original work and has not been submitted for a degree award in any other University or Institution of higher learning.

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DEDICATION

Let me take the opportunity to appreciate my wife TUYISHIME Blandine, our sons Ngombwa Randa Jax and Ndiho Nzeyi Elio and my beloved daughter AKARINGA Avah Lana for their unceasing tolerance for the entire time of my absence. I love you so much!

To my guardian Marist Brother Ngombwa, with your bright word to me "COURAGE" since my secondary studies until nowadays. "It led me to become who I am"

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LIST OF ACRONYMS

ACPC	-	African Climate Policy Centre
ALP	-	Adaptation Learning Program
CCAFS	-	Climate Change, Agriculture and Food Security
CGIAR	-	Consultative Group for International Agricultural Research
CDKN	-	Climate Development for Africa Network
CIS	-	Climate Information and Services
EICV	-	Enquête Intégrale sur les Conditions de Vie des Ménages (Integrated Household Living Conditions Survey)
GFCS	-	Global Framework for Climate Services
GoR	-	Government of Rwanda
IMD	-	Indian Meteorology Department
IPCC	-	Intergovernmental Panel on Climate Change
ITCZ	-	Inter-Tropical Convergence Zone
KIIs	-	Key Informant Interviews
Meteo Rwanda	-	Rwanda Meteorology Agency
NISR	-	National Institute of Statistics of Rwanda
NMHSs	-	National Meteorology and Hydrology Services
RAB	-	Rwanda Agriculture Board
RDB	-	Rwanda Development Board
SPSS	-	Statistical Package for Social Sciences
SWOT	-	Strengths, Weaknesses, Opportunities, Threats
UNFCCC	-	United Nations Framework Convention on Climate Change
UNISDR	-	United Nations International Strategy for Disaster reduction
USAID	-	United States Agency for International Development
WB	-	World Bank
WISER	-	Weather and Information Services for Africa
WMO	-	World Meteorological Organization

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ABSTRACT

Globally climate change has been a major constraint towards achieving food security. Therefore, adaptation to climate change is imperative to reduce farmers' vulnerability. The production and provision of climate information services (CIS) in Rwanda has increased, but their accessibility and utilization in decision-making have been limited. One approach to enhance resilience among the smallholder farmers is to provide them with timely, accurate and reliable climate information services through effective communication channels. This study investigated, among others, the Climate Information and Services (CIS) communication channels accessed by the smallholder farmers in Ruhango district of Rwanda; the farmers' social-economic characteristics which influence the accessibility of those channels and the factors inhibiting the use of the available climate information services effectively in decision-making. Also, this study assessed the available adaptation practices applied by the smallholder farmers to tackle the impacts of climate change experienced in their area. A total of 159 smallholder farmers were interviewed by using the Survey CTO computer software application installed in Tablets; while Key Informant Interviews (KIIs) tool was used to gather information extension officers. The study utilized primary data gathered from smallholder farmers and extension officers asked to answer the questions planned for the first, second, third and fourth objectives. All collected data were analyzed using SPSS for all objectives. The results showed that majority (91.2%) accessed of only the daily weather forecast where the radio was the main dissemination channel followed by mobile phone. Family size was only the socio-economic characteristic established to be statistically significant in influencing the accessibility to communication channels. Among the smallholder farmers that accessed CIS, only 11.9% used it. The majority (88.1%) of smallholder farmers who did not use the CIS said it is due from "lack of trust based on untimely and unreliable climate information received in previous years. While all the respondents (100%) were confirmed that "the Climate has changed. Only anti-erosion practices were reported to be dominant (53.5%) applied as adaptation practice. To enhance the farmer's trust in CIS, the forecasters should have paid special attention to know and meet the farmers' needs and the provision of accurate, timely and reliable climate information services to smallholder farmers should be the priority of climate information and services' providers.

Keywords: Climate change, resilience, weather information, climate services

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter presents the general introduction and background of the study, gives information on the study area and a brief highlight on climate change on agricultural systems, the problem statement, research questions, objectives, justification and signification of the research.

1.1 Background of study

Climate change is projected to have profound effects on food security, particularly in developing world where agricultural production supports majority of livelihoods, but also agricultural production is primarily through rain fed agriculture. An underlying mechanism by which climate change will negatively affect agriculture is through increased food insecurity, as both crop and livestock production are threatened by climate change. For centuries, most of smallholder farmers have been relied on indigenous climate knowledge to know when and where to plant crops. Unfortunately, this knowledge becomes inappropriate in face of climate change which affecting precipitation patterns, length of growing periods, and temperatures. Among other prerequisites, climate information services are needed to characterize climate risks and to inform decision-making for effective risk management. Climate information services can play a critical role in climate risks reduction and mitigating of such risks and impacts (Naab *et al*., 2019) Without access to accurate, reliable and timely climate information services, farmers face severe crops failures and food insecure in its all three dimensions (availability, accessibility, and usability) (Enete & Amusa, 2010).

Communication is a critical tool for reaching out to farmers and disseminating knowledge. The information, on the other hand, must be timely, well-prepared, relevant, and, most significantly, a key participant in interventions involving voluntary improvement in the targeted group's behavior. The improvement in behavior should be the product of the information obtained, and it should be reported to the source for further investigation (Epstein *et al*., 2018; Surabhi, 2013).

Numerous cases of the successful uptake of CIS shows that the climate information services are assisting farmers in managing short-term climate risks (McGahey & Lumosi, 2018; Naab *et al*., 2019)

To enhance smallholder farmers' resilience requires an effective climate information and services communication channel. The main challenges in using climate services include lack of reliable, accurate and timely weather and climate information, lack of awareness about the existence of specific local weather information, lack of understanding and capacity to use forecast information, and poor understanding of climate uncertainties (Amadi & Chigbu, 2014)

Thus, effort should be made to improve the provision of weather information services on one hand, and to consider the climate related risks during decision-making on the other hand. Effective communication of weather and climate information, for example, helps the farmers to know the planting time and increase farm production, mitigate and adapt to predicted climate risks in their area (Bharwani & Barrott, 2016; GFCS, 2016).Studies indicate that there is substantial demand for climate services among farmers in Africa (Amadi & Chigbu, 2014; Watkiss et al., 2019).

Agriculture is driving the livelihoods of majority of Rwandans where about 80% of the people are engaged in agriculture directly or indirectly and provides job to greater than 70% of the labor force. In recent past years the change in rainfall patterns resulting in heavy rains and droughts reduce significantly the agricultural productivity negatively impacting livelihoods and food security (Uwiragiye et al., 2019). Climate services therefore plays an important role in making relevant decision regarding adaptation about farm management and climate resilient development. Climate information can provide early warnings for early actions by integrating of climate hazards in advance(Watkiss *et al.*, 2019). According to the Global Framework for Climate Services (GFCS), building people's resilient capacity in the agriculture sector necessitates access to, comprehension, and use of CIS that are important to policy making (GFCS, 2016)

The frequent droughts and floods in Rwanda underscore the fact that change in climate patterns can destroy lives and properties. In order to build effective resilience against climate risks, climate information services are a critical input specially to ensure those vulnerable groups are more resilient, thus fostering sustainable adaptation practices among them.

Furthermore, despite the government of Rwanda's attempts to combat climate change, cases of malnutrition, especially among children, have been recorded in some Rwandan districts as a result of climate change. Food insecurity as a result of prolonged dry spells in Rwanda's eastern provinces and, on the other hand, heavy rainfall in the country's northern regions. According to various reports(Uwiragiye *et al.*, 2019). Africa is extremely vulnerable to climate change due to a variety of stresses and a lack of sufficient adaptation capability, which are caused by extreme poverty, insufficient resources of institutions, and living in conflict(FAO, 2019).

The Rwandan government has put in place climate change and adaptation plans. It is beneficial the implementation of policies that include components that contribute to the incorporation of CIS, local scale or indigenous knowledge, and agricultural extension interventions. The outcomes of such a mechanism would aid in ensuring that CIS is provided in a qualitative, quantitative, and continuous manner that is beneficial to farmers, enhancing their reliance and ensure food availability, accessibility and stability all over the country (Uwiragiye et al., 2019).

1.1.1 Channels of Communication

According to (Petronila, 2015) study, the contact for production in the agricultural sector, for example, is faced with a variety of communication tools and procedures that can be used to achieve particular goals. Entertainment-education, marital friends, peer education, social engagement, group actions, media activism, and even listening to traditional songs are some of the techniques used. The means by which messages pass from the sender to the receiver and vice versa are referred to as communication systems.

Personal communications, radio transmissions, newspapers, field days, farm exhibits, demonstrations, and other correspondence networks are used to disseminate agricultural information. These networks can be categorized into five groups. Seminars and exhibits are examples of physical networks that require close touch. Television, radio, telephone, newspapers, and other printed media outlets are examples of non-physical sources. Technical, which can be physical or non-physical in nature (Petronila, 2015) Ruhango district is located in the rural area with limited to non-existent facilities for access to information. The majority of homesteads lack basic utilities such as electricity and adequate road access. The use of a number of communication channels to communicate climate information to farmers is beneficial.

This is due to the fact that the many ways used in the communicating process, the more likely communication signals are to be heard (Petronila, 2015)

1.2 Problem Statement

Short-term weather forecasts, seasonal forecasts, and warning or alerts on extreme events can build reliable climate resilience in vulnerable communities. According to (Muema, 2018) in Sub-Saharan Africa (SSA), insufficient access to and use of CIS has been reported, and inaccessibility of climate information by smallholder farmers has been a major constraint in climate risk mitigation.

The smallholder farmers in Rwanda often say that the climate information services are not help enough in their farming operations. Although researches have revealed needs from farmers for climate related services (Amwata , Omondi, 2018); inaccessible information communication channels (Diouf *et al.*, 2019), lack of participatory and integration of stakeholders and end-users (Muema, 2018), and the large gap is to climate forecasting that do not meet the users' needs (Naab *et al.*, 2019). In 2017 the study on climate information access and use among smallholder farmers has been conducted in all provinces of Rwanda. The results showed that the farmers in Rwanda have little access to and utilize of CIS (Jeanne Y Coulibaly et al., 2017) .

The limitations and gaps in climate information services uptake and use on farm management and decision-making contributed to low values for resilience indicators which varies from 0.2 to 0.3 on a 0-1 scale. The farmers facing various challenges in using the climate information and services, they received. This is related to the poor quality of that information, not having the specific information at their local scale and difficulties in understanding and interpreting the climate information received. Lack of trust in generalized information issued by national meteorological agency and lack of locally relevant information have been said to be the main challenges preventing the farmers to integrate climate information into their agricultural decision-making. For CIS delivery to be effectively, (Rarieya & Fortun, 2015) stated that early information on climate conditions combined with relevant agricultural advisories, when communicate on timely to farmer, have an extraordinary impact on farmers' resilience. They argue that the whole integration of climate information services is a strong tool to allow vulnerable communities to mitigate the risks. Climate information is most useful for farmers if it is effectively communicated through a range of channels, including ICT tools (Radio, TV, Mobile phones), trained agricultural extension agents.

Social media is emerging as a new way to reach out to young people engaging in agriculture sector because they are learning and using the latest technology faster than old people (Catherine Mungai, 2018). Therefore, there is need of more localized climate information services studies in Rwanda where literature on climate information services dissemination and communication is a little scarce.

1.3 Research Questions

The study addressed the following questions:

- **(i)** What are the most common communication channels of climatic information for smallholder farmers, and what is the accessibility of this information in Ruhango District?
- **(ii)** How do the socio-economic characteristics of smallholder farmers influence access to climate communication channels in Ruhango District?
- **(iii)** Which factors affect the use of the available climate information services by smallholder farmers in Ruhango District?
- **(iv)** Which adaptation practices are applied by smallholder farmers used to tackle the climate change effects in Ruhango District?

1.4 Objectives of study

The main objective of this research was to enhance resilience of smallholder farmers in Ruhango district through effective climate communication channels. The Specific Objectives were to:

- **(i)** Assess the climate communication channels used by smallholder farmers in Ruhango District.
- **(ii)** Examine the socio-economic characteristics of small holder farmers that influence the accessibility of climate communication channels in Ruhango District.
- **(iii)** Determine the factors that hinder the use of the available climate information services by smallholder farmers in Ruhango District.
- **(iv)** Identify the available adaptation practices applied by smallholder farmers to tackle the effects of climate change in Ruhango District.

1.5 Justification and Significance of the Study

Smallholder farmers in the developing world will be disproportionately impacted negatively by climate change. For centuries, most of these farmers have relied on indigenous climate knowledge to know when and where to plant crops. Unfortunately, climate change has already made this perception inappropriate by modifying rainy seasonal trends, length of growing periods, and temperatures. Climate information services are critical for climate risks in reduction and mitigating such risks and impacts. Without accurate and accessible climate information services, farmers face severe crop failures, increased hunger, malnutrition and various diseases.

This study aims to enhance the Ruhango district's smallholder farmers' knowledge to better build their resilience through the access and use of CIS through effective channels of communication. The climate communication channels accessed by the smallholder farmers were assessed. The study can lead to better understanding of the various channels being used in dissemination of climate information services by Meteo Rwanda, how accessed and used in farm decision making and determined the adaptation practices adopted by smallholder farmers.

The findings of this study will help national and district officials overcome the different barriers that smallholder farmers face in accessing and using climate information resources. Furthermore, this study would support the IPCC's call to prioritize research that enhances farmers' adaptive potential in Africa. Finally, the results of the study have contributed to the current literature on climate access to and use of. Other researchers who will studying various aspects of climate information systems will use this paper as a reference.

1.6 Research limitations

It's important to acknowledge the limitations of this study. Due to research limit budget, this research was conducted in only one district in the whole country. This research only focused on radio, television, mobile phone, internet, workshop/training, agriculture extension services, farmer-to-farmer as climate communication channels but it did not consider the other channels which might also have positive impacts.

1.7 Overview of the Methodological Approach

To achieve the specific objectives mentioned earlier, the following two research methods were used:

1.7.1 Household interviews

At household level, semi-structured interview questionnaire was used through survey CTO (computer application) by using tablets to probe householder ‘s socio-economic characteristics and capture information on climate channels accessed by local Smallholder farmers and how they are using that information in decision-making for their farm management; why climate information services were not effectively use of in farm decision making, and what adaptation practices adapted to tackle the climate effects in Ruhango. This method is preferred because it ensures confidentiality and privacy on the part of respondents and this approach made it easy for the researcher to reach the appropriate sampled population (Ranney *et al*., 2015).

1.7.2 Key Informant Interview (KII)

The KII was conducted through in-depth interviews to acquire more information about how climate information services disseminated from national level (Meteo-Rwanda) to smallholder farmers are used. This technique was used to acquire more information from climate service providers, and agricultural extension agents to understand why climate information services were not effectively use of in farm decision making. Key informant interviews include interviewing a small group of people who are likely to have the knowledge, ideas, and perspectives required on a subject. There are only a limited number of informants because they have details or suggestions that the investigator may seek (Kumar, 1989).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The relevant studies that were considered useful for the research are reviewed in this chapter. It should be noted that Sub-Saharan Africa (SSA) is very prone to climate variability and change and is quite vulnerable to climate change. And it is projected to be severely impacted upon by future climate changes and extreme weather events. These climate effects could significantly magnify the poverty level and set back the 2030 sustainable development agenda. Climate information services are highly importance input for policies-makers and communities to prepare for and reduce the negative impacts of those extremes events, it can help to reverse this trend and enhance climate resilient. The sections below review key concepts and practical examples of successful use of climate and weather services received in managing climate related risks.

2.2 Climate change in Rwanda

With a moderate climate and relatively high rainfall, Rwanda is a landlocked country. Temperature increases, increased precipitation, and prolonged dry seasons are likely to occur from climate change. This poses multiple issues for different regions: the country's mountainous west will be prone to erosion, serious floods will occur in parts of the central north and south, and east will be susceptible to erosion and southeast will suffer from droughts. Some effects of climate change are expected to change levels of lakes and stream flow, and forest degradation. Rwanda's current rainfall pattern indicates a high average rainfall of over 1500 mm in the country's mountainous regions and just below 700 mm in east part of country.

Four seasons describe the country's rainfall pattern: a short-wet seasonal period (September-November), a short dry season (December-February), a long wet seasonal period (March-May) and a long dry season (June-August). The average annual temperature in Rwanda is about 15-17 ° C in high altitude areas and up to 30 ° C in the eastern and southwestern lowland areas. Analysis of precipitation patterns has shown a rising frequency of extremes over time and in different regions of the nation. Rainy seasons, particularly in the northern and western provinces, has become shorter and more intense, which raises the risk of erosion in these mountainous areas of the country.

Over the past decade, eastern regions suffered extreme rainfall declines in a number of years (Warner *et al*., 2015). The current rainfall and temperature patterns are anticipated to continue in the future. The temperature projection, suggested that between 2000 and 2050 the country's temperature will increase another 1-2.5 ° C, and 1-6 ° C by 2100. The increase is expected to be consistent across the country and across seasons, although the rise might be slightly higher in the long dry season than in other seasons (Byishimo, 2018).

2.2.1 Climate information services

Current weather observations, short-term predictions or forecasts, and medium- to long-term climate models are all examples of climate information (Muema, 2018). The distribution of reliable weather and environmental status, as well as a variety of consulting services that can assist decision-makers in understanding and responding to information in a relevant operational context, are examples of 'climate services', as we refer to them (Naab *et al.*, 2019) .

A climate service must consider and engage users in order to appreciate their interests, as well as include them in the co-design and co-evaluation of services and products and develop appropriate communication channels(Singh *et al*., 2017). Although some approaches estimate the value of CIS in terms of the anticipated in economic growth possible benefits to agriculture go beyond financial outcomes, but to also social and environmental status. For smallholder farmers, the economic gain of climate information largely comes from adjusting management in ways that increase output or profits or minimize production costs (Naab *et al.*, 2019); (Reay *et al*., 2007) . Some of the social benefits include improvements in farming practices (e.g. cropping schedule) and improved preparation of farming operations (e.g. scheduled spending of money and improved management of labor), as well as improved food security and other livelihoods benefits related. Efficient use of climate services may also have an environmental benefit.

2.2.2 Approaches to climate information communication services

In Africa and Asia, factors such as communications strategies (channels, styles, and templates) and contextual factors such as indigenous information, local cultural activities and behaviors (such as beliefs), community livelihood processes and experiences, and gender all play a role in the accessibility of climate information resources.

The type of communication channels used to communication climate information determined its usability. The various channels including television, radio, field shows on the farm, groups information sessions (schools and religious institutions), Face-to-face communications, as well as cell phones and social media, have been more common in recent years(ASSAR, 2015a).

The usefulness of CIS is influenced by the intrinsic features of these information channels, types and formats. When climate information services are transmitted in a non-local language, for example, the study showed that it is difficult for populations to comprehend and react to the information disseminated (Singh *et al*., 2018). Seasonal forecasts (e.g. onset of rains) targeting agricultural development, early warnings of imminent disaster events (drought, floods, etc.) focused on mitigating the effects of disasters, raising public awareness and triggering emergency responses are some of the information shared across these channels. Climate information is generally understood by most recipients using local languages, Radio has emerged as the most common mode of communication among communities in Africa and Asia (AGRA, 2014).

Climate and weather information is made more accessible by face-to-face communication forums such as meetings and community gatherings, as well as by the use of intermediaries such as extension service officers. Local farmers have noticed that climate information services delivered by music, drama, and plays are easier to interpret and enable people to engage with the information even more quickly (McGahey & Lumosi, 2018); (Kom *et al*., 2020) . The timing of the release of weather and climate information could also be essential to its usefulness. This suggests that all of the individual qualities of climate information, such as the medium by which it is transmitted, the manner through which it is communicated, the timing and degree of accuracy in which it is communicated, and the actual possibilities for people to access this information, are all affected (ASSAR, 2015b).

2.2.3 Role of Communication Channels in Disseminating of Climate Information

Climate Information is critical to agricultural growth and productivity, and effective communication between farmers, agriculture scientists, and extension staff would help common understanding. Increased agricultural production and productivity require a cornerstone of climate knowledge and information.

Mass media, advertisements, government departments and agents, as well as casual contact, have all played a significant role in disseminating farm-related information to other farmers. If farmers want to progress beyond their current level of productivity, they will need climate information. A steady flow of reliable, understandable, credible information connects scientists and farmers via the different sources that convey that information (ASSAR, 2015a).

Radio, television, newspapers, all from government or private channels, are among the climate communication channels used by smallholder farmers. Personal interaction is often made with extension staff and commercial company members, either individually or in small groups. Exhibitions, conferences, lectures, and demonstrations are also examples of this. There may be personal interactions with other farmers as well. According to studies, mass media communications systems are essential for conveying knowledge, building perception, and shifting cognitions, while interpersonal communication channels are more likely to trigger attitude change. Radio has been discovered to hit the biggest population in the majority of developing countries (Petronila, 2015).

Radio could simultaneously attract a wide audience. When opposed to other extension media and approaches containing human and group contacts, it is an incredibly cost-effective tool. Radio is often regarded as a reliable source of information, as well as an accurate, dependable, and prestigious means of communication. The term "credibility" refers to the trustworthiness of info that farmers regard as relevant and consider when deciding whether or not to follow it. Farmers consider agricultural technology as admirable, which has influenced its adoption, However, television and radio, as well as various newspapers that print articles and publications on agriculture, play a vital role in disseminating CIS to farmers (Petronila, 2015) said.

According to research, cell phones provide farmers with a forum for exchanging and receiving agricultural knowledge. Farmers today use their cellphones for a variety of purposes. Some use it to get commodity prices from the industry, and some use it to connect directly with consumers in order to sell their products at a higher price. Furthermore, farmers use short text message (SMS) to make informed decisions about the climate and pesticide use on their farms. Since the majority of small- farmers are uneducated, social interaction is the primary process of communicating them. Village messengers, and word of mouth were discovered to be more common among smallholder farmers. Traditional ways of communication, such as folk songs, plays, and sermons, have credibility and significance in traditional cultures that cannot be matched by imported technology. (Petronila, 2015) has said that young farmers had a more lot of positive feedback to the relevance, practicability, and accuracy of knowledge presented by agricultural publications than older farmers. He also came to the conclusion that, on the whole, there is a need to enhance agricultural publishing standards regarding of practicability.

2.2.4 Principles of Climate Information Services

One of the first tasks for the climate information services' team and the Consortium as a whole was to come up with a list of agreed-upon "CIS standards." This process sought to explain some of the Consortium's core CIS concerns and provide direction for the program's progress. The principles are as follows:

- **(i)** The production of accurate probabilistic information (ignoring probabilistic nature of information will lead to a potential loss of trust);
- **(ii)** Using and comprehending probabilistic and unreliable information (ensuring that people have a clear understanding of prediction uncertainty);
- **(iii)** Useful information (timely climate information services delivery, tailored to specific users);
- **(iv)** Appropriate CIS availability and two-way access (improving or establishing access through established delivery networks) and
- **(v)** Have trust (gained by combining all the above thus collaborating together to share information with local people in a participatory manner) (Mittal & Mehar, 2016).

2.2.5 The principles for public engagement in climate services

Uncertainty is an aspect of climate science that cannot be overlooked or dismissed, but it can be a significant roadblock in discussions with non-scientists. Prioritize the ‘knowns' over the ‘unknowns,' and emphasize areas of broad scientific consensus on a given topic. Focusing about what is understood (even though it is ‘old news') before addressing uncertainties is one easy way to guarantee the ambiguity does not derail a convincing story.

The essence of scientific inquiry necessitates this (where a premium is placed on exploring new areas rather than repeating established statements of fact), most scientific communication attempts to dwell on what scientists don't realize before emphasizing points of consensus. However, this may give the appearance that scientists disagree on the fundamental details of an issue. Uncertainty of science is often misinterpreted by the population as confusion, and it is well known that members of the public in many countries worldwide dramatically overestimate and overlook the uncertainty associated with climate change science as well as underestimating the degree of scientific agreement (Corner *et al*., 2018).

Leading with a focus on what is known:

Don't Lead with the unknown
“Although there is a great deal that is unknown about how local services in (town where you are speaking) will be affected, climate change is likely to lead to heavier downpours and more flooding in the future.”

Do Lead with what is known
“The risk of heavier downpours and more flooding in (town where you are speaking), disrupting your businesses and schools, is now higher because of climate change.”

The relationship between weather and climate is an excellent example of how to communicate effectively in the face of uncertainty. Extreme weather conditions will provide concrete indicators of climate change and provide an impetus to discuss climate threats, but they must be discussed with caution: after being faced with "evidence from their own eyes," people are also skeptical of climate change. Extreme weather conditions are subject to the same political polarization that plagues other aspects of climate communication. Talking about the proven links with weather extremes can be an incredibly effective way to apply climate change to our daily lives if done carefully and thoughtfully, sticking to the science and avoiding excessively technical terms(Corner *et al*., 2018) Talking about extreme weather events: Climate scientists are getting better at quantifying the relation between severe weather and climate change. It's critical to communicate the increasing trust in attribution (rather than beginning from the stance that "no particular weather occurrence is triggered by climate change," which was the conventional answer previously).

Talking about the relation between weather and climate is important when science allows, but preferably before (rather than during or after) an extreme weather event. This tends to normalize the concept and keeps communicators from coming off as opportunistic. Extreme weather does not transcend people's cultural and ideological filters for interpreting the world; it's also crucial to know the audience's beliefs and structure your discussion of extreme weather situations using vocabulary that appeals to such values(Corner *et al*., 2018).

The ‘visual language' of climate change is incredibly significant, just as the language you use has a strong effect on how people conceptualize climate change. Polar bears, melting ice sheets, smokestacks, and potentially polarizing photos of radical protests are currently used to portray climate change in the public imagination(Corner *et al*., 2018).

2.3 The role of National Meteorological and Hydrological Services

National Meteorological and Hydrological Services (NMHSs) should take advantage of climate services and their ability to support benefits for sustainable development as countries move towards implementing National Adaptation Plans (NAPs). Once provided with improved information on the environment, water and climate, nations can make stronger, more informed decisions in climate-sensitive fields, thus eventually leading to both Major economic opportunities and sustainable growth. Not only can this save lives and protect properties, but it can also increase protection, productivity in agriculture and water security. In several economic and social fields, the successful creation and use of CIS will serve as a valuable decision-making aid. Science-based and user-specific information on past, current and possible future climates is generated by climate services and discusses each climate-affected sector at global, regional and local levels. These services collect high-quality data from nationally and internationally databases and maps on temperature, rainfall, wind, soil moisture and ocean conditions; risk and vulnerability analyses; assessments; and long-term forecasts and scenarios (GFCS, 2016). These data and information products can be mixed, depending on the needs of users, with non-meteorological data on agricultural development, health patterns and human settlement in high-risk areas, infrastructure and other socio-economic aspects.

To help individuals and to make decisions, climate services translate the data and information they have gathered into personalized products such as forecasts, patterns, economic assessments and services for different groups of communities (Amadi & Chigbu, 2014) . Climate resources should not only functionally access and respond efficiently to the needs of users, but also engage users appropriately. Such programs help to ensure that climate-smart choices are taken by user groups and that climate information is transmitted in an efficient manner that makes practical action easier (Amegnaglo *et al.*, 2017). Climate resources that provide specific info, for example, will allow farmers to improve planting and marketing strategies, enable authorities to prepare more effectively for natural disasters such as droughts and heavy rainfall, and ensure better water resource management. In addition, in order to reduce outbreaks of climate-related diseases such as malaria and meningitis, they will help public health agencies prepare vaccination and prevention campaigns. Such practices lead to effective adaptation preparation in a changing environment (McGahey & Lumosi, 2018).

On average, droughts and prolonged dry periods have cost Malawi annually around 1% of Gross National Product (GNP) and have contributed to a 1.3% rise in poverty (Kalanda-Joshua et al., 2011). Devastating floods caused more than 170 deaths and the displacement of 246,000 people in 2015 alone, as well as widespread damage to crops, livestock and infrastructure. Despite the severity of such disasters, the efforts of the Global System for Climate Services have been introduced in Malawi. By strengthening the connection between the National Meteorological and Hydrological Services and the user community, the Adaptation Program in Africa has helped individuals prepare for and respond effectively to flooding. It helps to develop user-driven climate services for the mitigation of disaster risk, food health and wellbeing (Kom *et al.*, 2020).
In Ghana, Kenya and Niger through Adaptation Learning Program (ALP) for Africa together with the NMHSs provided the climate services considering crop-specific and locally relevant to smallholder farmers and information considered of end user's socio-economic benefits. This communication approach has led to relevant actions as when and what to plant (Amadi & Chigbu, 2014). In Ethiopia a high likelihood seasonal forecasts of drought of 2002 have prompted meetings concern stakeholders to identify specific actions before that situation become severe.

Seasonal forecast used by Mali extension agents has led to income gains up to 10% and above of agriculture production and in Zimbabwe the seasonal forecast effective communication has led to increase about 9% in production (Klein *et al.*, 2015). The native populations of a particular place are internationally recognized as extremely vulnerable to the effects of climate change, but are also recognized as having specific information to be used for climate adaptation. Farmers have historically based their decisions about plant and water systems on local climate pattern information (Singh *et al*., 2018). Extensive information networks have been developed by groups exposed to extreme weather and hazard incidents and/or highly dependent on local agriculture to inform farming decision-making and also preparedness and recovery activities. This expertise produces highly locally relevant climate information and common experience and learning that is gained over time. This awareness has been found to play an important role in the community's livelihoods and development. At the same time, the lack of this information has been found to threaten farmers' capacity to adapt to climate change impacts, highlighting the value of identifying existing traditional knowledge that informs decision-making in the design and implementation of climate information services (Rahman & Hickey, 2019) .

2.3.1 Accessibility to and use of climate information services

Climate service usability requires strong communication between the information provider and the users (Diouf *et al*., 2019);(Muema, 2018). In Africa, however, there are still substantial gaps due to socio-economic characteristics, lack of capacity to interpret weather and climate information systems, and weak integration of current ways in which societies view and decision (Churi *et al*., 2012). Timely and accurate access to climate information can help farmers cope with extreme events and reduce socio-economic disruptions and harm associated with them. The National Hydrological and Meteorological Services (NHMS) must make sure that the information on the climate is transmitted accurately to end-users. The CIS will also allow people to build their resilience and take advantage of the benefits and opportunities that climate conditions can offer.
This helps to ensure long-term sustain life or decision-making capacity in order to minimize the processes recognized as "mal-adaptation" of the population. End users require access to and understanding of how to use climate information (Bryan & Behrman, 2013).

Accessing and interpreting climate information and using it are often major challenges, mainly because climate information from climate science is often driven by NHMS, not by users, so the information does not fulfill the needs of users who use it for decision-making and planning. And part of the challenge of climate science is that the level of precision and certainty of information varies. Uncertain future climate information is considered an obstacle to the use of information, even though it is more useful for preparation than no information at all(Mburia, 2015). In recent years, Rwanda has been faced by vagaries of a climate crisis.

Thunderstorms, floods, strong winds, heavy rains leading to landslides, longer dry seasonal patterns and altered weather patterns are becoming more frequent, making seasons more erratic and no longer sufficient conventional indicators. This has many implications for Rwanda's largely rain-fed farming sector, which is also the primary source of subsistence for the majority of the population of the country. Agriculture accounts for 30% of GDP, while shepherding, practiced only in small pockets of dry areas, accounts for 10% of GDP (Jeanne Y Coulibaly et al., 2017) . The effects of climate variability in Rwanda, particularly in the agricultural sector, are becoming increasingly noticeable. However, farmers have often referred to the lack of access to the appropriate climate information as the reason why they are still unable to handle risks for better crop yields (Jeanne Y Coulibaly et al., 2017).

2.3.2 Challenges for availability of climate information services in Africa

(i) **Inadequate Infrastructure:** In many countries, observations do not cover spatial variability in order to adequately cover the climate zones of the countries and do not have sufficient detailed weather information for informed decision-making. For instance, Malawi's automatic rain gauges and ground stations are concentrated in half of the country (Western) only since there are no rainfall stations in other locations. In Tanzania, information regarding climate is sent by email to the Ministry of Agriculture and comes too late for any effective analysis, early warning or short-term plan (Churi *et al*., 2012).

Countries typically have few automated weather stations (AWS). There are eleven (11) AWS in Tanzania that cover the region, while Zambia has two. While there are 10 AWS in Sao Tome & Principe, only 3 are operating (Singh *et al*., 2018). The accuracy of forecasting over Africa is jeopardized because of poor coverage with insufficient equipment, low density of monitoring stations coverage, this involves coverage by international systems. As a result, Africa is not sufficiently linked to global weather and climate platforms, with a limited contribution to global climate studies (Singh *et al.*, 2017).

(ii) **Inadequate Finance:** Unfortunately, limited investment goes into the meteorological agency's infrastructure and capacity, given that many African countries have other priorities, such as achieving more immediate targets, they tend to spend in other fields, such as infrastructure, which have a more concrete effect and return.

(iii) Burkina Faso's Aeronautical Aviation Radar and Cloud Seeding Center (SAAGA) failed due to a lack of financial planning to cover cost of maintenance for the Ouagadougou' Radar, where about 40% of the hydrological stations aren't functioning properly. In Malawi's national budget, there is very no funding for emergency response and hydro-meteorological Early Warning Systems. As a result, there has been i) A steady decrease over the last 20-30 years in the system of the hydro-meteorological observation networks in Malawi; and ii) insufficient amount of funds from the Department of Disaster Management Affairs to accomplish its core mandate in collaboration with the Department of Climate Change and Meteorological Services and the Division of Water Resources. The quality of the climate information infrastructure therefore is deteriorating in many African countries, and meteorological departments often have to work with insufficient resources, including old systems, staff and machinery. Not only does this impact the performance of workforce, but it also affects the consistency and authenticity of the results produced (UNECA, 2016).

(iv) **Limited of technical capacity to manage climate information systems:** A high-quality job and several years of education and training are needed to run forecast models. In Uganda, due to its limited in human resources and expertise, use of satellite data to forecast precipitation or track convective processes resulting in extreme storms is unavailable; the dissemination of information to places not covered by hydrological and meteorological stations; Environmental variables farming and meteorological threats, such as satellite-based flood mapping, are observed.

Because of the poorly organized condition of the sub-sector, low-capacity development, and inadequate funding, well-trained meteorologists are often unable to use their abilities effectively (UNECA, 2011).

Poor translation, coordination and distribution of climate information services: Malawi has a Flood Early Warning System where many flaws lead to delays in sending out early warnings. These include, but are not limited to, Limited district-level awareness on what to do in the case of an emergency alarms; limited standardization in the transmission of early warning notifications; and limited cross-border collaboration with Mozambique on tropical storms, floods, mere storms, and rain deficiency. There is no simple mechanism to transmit meteorological information to the communities.

At the national level, alerts are given, going through a variety of agencies and several organizations. Processing data across different departments leads to a delay, failing to achieve the expected emergency alert objective (Res & Lu, 2011). The Tanzania Meteorological Agency (TMA) in the Ministry of Water, where the Water Basin Authority currently operates and manages its own observation stations, is an example of poor administrative cooperation, leading to duplication and high costs (Adele & Todd, 2011). The surveys conducted by CIAT-Rwanda shows that the farmers in Rwanda have little access to CIS. The limitations and gaps in CIS uptake and use on farm management and decision-making contributed to low values for resilience indicators which varies from 0.2 to 0.3 on a 0-1 scale (J Y Coulibaly *et al*., 2017).

2.4 Factors affecting access to and use of Climate Information Services

The possible use of climate information services in strategic decisions across many socio-economic sectors has been reported in many studies (Muema, 2018) . It emphasizes that climate information services will serve indirectly as an input into regional and national early warnings, but also directly as a basis for improving community's resource management. Farmers need timely, reliable forecasts, and the information and understanding to use them to reduce the likelihood of agricultural (e.g. crop) loss caused by climate change and fluctuations.

Access to accurate climate information is critical for anticipating climate-related challenges and building resilience. As such, the Creating Resilience and Adaptation to Extreme Weather and Disasters (BRACED) program is recognized as an important contribution to funded projects (Passi *et al*., 2013). However, end-users face various challenges when using the information, they already received. This contributes to the availability of the information products, the lack of adequate scale of information and the difficulties of communication and interpretation of the information generated. Climate information from national and community levels should be client and incorporated into decision-making (Catherine Mungai, 2018). If the information is adjusted to meet the needs of the farmers, proposed changes in climate information are expected to result in change in behavior and strengthened resilience.

2.5 Climate information services and adaptation to climate change

Extreme events are now holding lives, wellbeing and resources at higher risk, and in some ways, these events are becoming much more frequent. Building resilience to expected disruptions as well as those who are unable to rely on our ability to withstand extreme events currently and adapt to future changes. This includes short, medium to long term decision-making based on scenarios, Predicting the challenges and possibilities associated with these and the uncertainties. There are several starting points, but improving the availability, accuracy and the use of climate information is an obvious point (Muema, 2018). Climate and weather data is covered by a wide range of data sets, methods, and infrastructure. In order to address problems related to the relevance of weather and climate information for decision-making, it is necessary to understand what kind of information is applicable as well as the fundamental technical and science complexities associated with accessing such information (Singh *et al*., 2018). Farmers have a long tradition of adapting to changing climates. Farmers can deal with current climate instability and possible climate change using both traditional and recently adopted adaptation practices.

The controversy about small-scale farmers' climate change adaptation in Africa, on the other hand, has arisen in the absence of awareness about current and future adaptation practices. It's difficult to do adequate studies on future adaptation practices and formulate effective recommendations for introducing new practices because existing theories regarding adaptation are vague. Farmers follow practices at the local level, with seasonal climatic fluctuations, the agricultural development, and other socioeconomic factors influencing their spread; the country, NGOs, or private firms implement practices globally, Seasonal climatic patterns, the food production environment, and other socioeconomic aspects influence their spreading, with long-term changes in climatic and other conditions influencing their establishment (Below et al., 2010) . Complex adaptation mechanisms are used by African smallholders. Agricultural adaptation is developmental, and it occurs in the context of different climatic, environmental, technological, social, and political forces. The majority of adaptation strategies have many functions and are intricately related. Furthermore, rather than a mechanical adjustment to a current state, adaptation is an incremental, dynamic, multiscale, and multi-actor process. It's impossible to tell whether a farmer's decision to cultivate one crop variety rather than another is a coping solution to short-term drought (climate variability) and when it's an expected reaction to climate change due to the complex nature of adaptation (Global instability is on the rise, as are long-term shifts in climatic conditions.). Adaptation is multi-actor since it includes a wide range of players, including farming residents, private enterprises, NGOs, and state, federal, national, and foreign governments (Below *et al*., 2010).

2.5.1 Adaptation options

(i) **Tactical adaptations:** Tactical adaptations are often distinguished by best management practices that are already available and can be introduced at low cost and in a limited time frame. There are mainly management options already being used by farmers to respond to current climate variability.

Since farmers are adjusting to climate variability from year to year, these management strategies are expected to occur naturally in the short-term and no policy or interference in research. When environmental variables are similar to the scope already encountered by farmers, this form of autonomous adaptation is quite successful for mild climatic changes. Changes in planting calendars, changes in cropping systems, use of conservation agriculture, increase in soil irrigation and drainage management, change in soil and pest management are potential tactical adaptation solutions (Rahman & Hickey, 2019).

(ii) **Strategic adaptations**: Additional investment and use of technology already available but not yet adopted into most development systems is required for strategic adaptation options. In the mid-term, advantages arise and costs are greater than that for tactical options. It is expected that such adaptive strategies are most successful at higher levels of extreme weather events.

Strategic adaptation strategies include changes in crop species, the production of new genotypes that are resilient to the environment, the enhancement of the use of precision farming, the introduction of monitoring and forecasting systems, and the advancement and expansion of irrigation (Rahman & Hickey, 2019).

(iii) **Transformation adaptations:** When geological, social or economic conditions becomes unsustainable, transition adaptation options resulting in a better risk and long-term investment and returns are needed. In addition to intense modifications, they are likely to occur. Implementing such options may require large-scale investments in research and infrastructure, or may require major systemic changes in agricultural production systems.

Both include the development of modern cropping systems and the development and implementation of emerging technologies (e.g. migrating to different land uses and economic activities) (Rahman & Hickey, 2019).

In the literature, a wide range of climate change coping strategies are proposed. 104 different climate adaptation practices were found after a study of 17 studies that contained data from more than 16 African nations, the United States, Europe, and Asia. The number of activities reported in each study varies from one (detailed) to as many as 29 (analyzed comparative). Changes in people's actions, societies' behavior, and organizations' activities, as well as the use and development of technology, are all part of the processes.

They require substantial and less visible changes to conventional farming practices, such as the use of native plants, as well as big adjustments in natural resource management, such as the construction of large irrigation ponds. Since adaptation happens at several levels and involves multiple players, introducing or adjusting crop insurance, as well as international grain futures markets, and making simple changes in the combination of common crops planted in a single region, can also help smallholder farmers in Africa respond to climatic changes.

(Okumu, 2013) Sort the behaviors of adaptation into the five groups below, which are not mutually exclusive:

i. Technology and farming management;
ii. Managing farm expenses;
iii. Agricultural diversification both on and off the farm;
iv. Government initiatives include improvements in rural infrastructure, rural health care services, and risk mitigation for rural residents;
v. Policy, networks, and strategic leadership

2.5.2 Adaptation to Climate Change

Climate change adaptation, especially in agriculture, has become a hot topic in recent development debates. As a result, it was enshrined in the UNFCCC and the Kyoto Protocol that followed in 1997 as a solution policy.

Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are required to:

Take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, ..., with a view to minimizing adverse effects on the economy, ..., to mitigate or adapt to climate change.

The advent of climate change modifications to political currencies is attributable to two factors: developing countries are extremely vulnerable to the impact of climate change because a large portion of their economy is dependent on it, and they have little adaptive potential(Reay *et al*., 2007). Adaptations are changes in natural, societal, and economic environments as a result of real or anticipated climatic stimuli, as well as their consequences and impacts. As a consequence, adaptation has the potential to reduce the detrimental impacts of climate change on human health and well-being while still increasing the capacity to take advantage of opportunities.

In terms of human aspects, climate change adaptation involves shifts in socio-economic structures that reduce the susceptibility of families, populations, organizations, industries, territories, or countries to climate-related changes. The aim of climate change adaptation is to strengthen societies' resistance to various types of climate change. Resilience is described as the capacity to maintain competent functioning in the face of significant life stressors (Klein *et al.,* 2015).

As a consequence, it demonstrates human systems' or individuals' capacity to bend without breaking in the face of disruption and, if bent, to revert to a stable state prior to the disruption. Unlike natural ecosystems, human environments have the ability to anticipate and react to future environmental changes. When a social or ecological system lacks its strength, it becomes more vulnerable to changes that it could historically tolerate and respond to.

Human survival on the planet is dependent on stable socio-ecological environments, which are determined by human resources and institutional structures (Klein *et al.*, 2015). (Klein *et al*., 2015) distinguishes three different types of adaptation: First, autonomous or spontaneous adaptations are those that emerge spontaneously after initial impacts to climatic stimuli, without the intervention of government policy. Second, before the consequences of climate change become noticeable, positive or anticipatory adaptation takes place. Third, intended adaptation is based on the understanding that conditions have changed or may strengthen, and that intervention is required to return to, maintain, or achieve a desirable environment.

However, due to institutional constraints, planned adaptation has been slow to arrive in many developing countries, and households are the most vulnerable to disrupted agricultural production (Okumu, 2013).

2.5.3 Impact of Climate change on crop productivity

Global climate change predictions, especially in terms of future rains, floods, and droughts, remain unpredictably uncertain. In the other hand, temperature predictions are more accurate. Sub-Saharan Africa's average annual temperature is projected to increase higher than the global average in the near future (Reay *et al*., 2007). Nonetheless, the climate is shifting, and there is widespread agreement that the future climate will not be the same as it is now. As a result, the precautionary principle must be applied and the risks of not intervening are certain to be incalculably high.
The key climate change-related factors that affect agricultural productivity are spatial and temporal variations in precipitation and rising temperatures (Kom *et al*., 2020) . More soil moisture deficits, crop degradation, and crop diseases, as well as more erratic and heavy rainfall, and a greater frequency and severity of extreme climatic events, will result from rising temperatures (Singh *et al*., 2018). These risks, however, may be significantly minimized with proper planning and proper maintenance of agricultural systems. According to recent estimates, for every 1°C rise in average temperature, dryland farm income in Africa will drop by nearly 10%. Similarly, in certain countries in Africa, rain-fed crop yields could be halved by 2020, and crop net income could plummet by 90% by 2100 (Byishimo, 2018). Droughts and floods are extreme climatic conditions that pose a threat to the agriculture system and can result in both persistent and transient food insecurity. This is because climate variability affects many crops' annual cycles and yields, including rainfall and temperature. Rural communities that depend on rain-fed crops would be much more susceptible to food insecurity as a result of climate change (Reay *et al*., 2007).

In developing countries, subsistence and smallholder farmers used to be able to make crop management decisions based on conventional expertise and environmental indicators. Increased rainfall variability in recent years, however, has disrupted these patterns in many areas, leading to local food shortages and rising the vulnerability of these populations. They need access to accurate weekly to seasonal information on specific variables such as precipitation and soil moisture that they can easily understand and respond on in order to schedule which crops to cultivate, the correct timing for planting, and to make the most of any possibilities such changes can offer. To promote the adoption and utilization of this information, it must be strongly contextualized, capturing local climate patterns and their interactions with other variables such as socio-economic trends, local awareness, and presented in a way that is both available to people (including those with low literacy) and usable, fitting into existing knowledge structures (combined with conventional knowledge) (Naab *et al*., 2019).

CHAPTER THREE: DATA AND METHODS OF ANALYSIS

3.0 Introduction

This chapter presents the specific methods and conceptual framework used in study. The methodological approach, data used, sampling process, data collection methods and analysis techniques used in the study are also highlighted.

3.1 Description of the study area

Ruhango is a district in Rwanda's Southern Province. Ruhango city, a large settlement on the road between the district Muhanga and Huye, is its capital. The district is located north of a provincial capital of Nyanza, on the main road from Kigali to Bujumbura. It is located at on Latitude 2° 13' 24" S and Longitude 29° 46' 41" E, Latitude -2.223333 and Longitude 29.778056, elevation of 1782m. Ruhango District is located in the Southern Province and shares the limits with Muhanga, Nyanza, Bugesera and Kamonyi districts at the north, south, north-east, and at east respectively, Nyamagabe at the south west and Karongi at the west (for Western Province). Ruhango District has nine sectors namely Kabagari, Byimana, Bweramana, Mbuye, Mwendo, Ruhango, Kinihira, Ntongwe and Kinazi sectors. The Ruhango district has fifty-nine cells and 533 villages. It covers a surface area of 626.8 square kilometers.

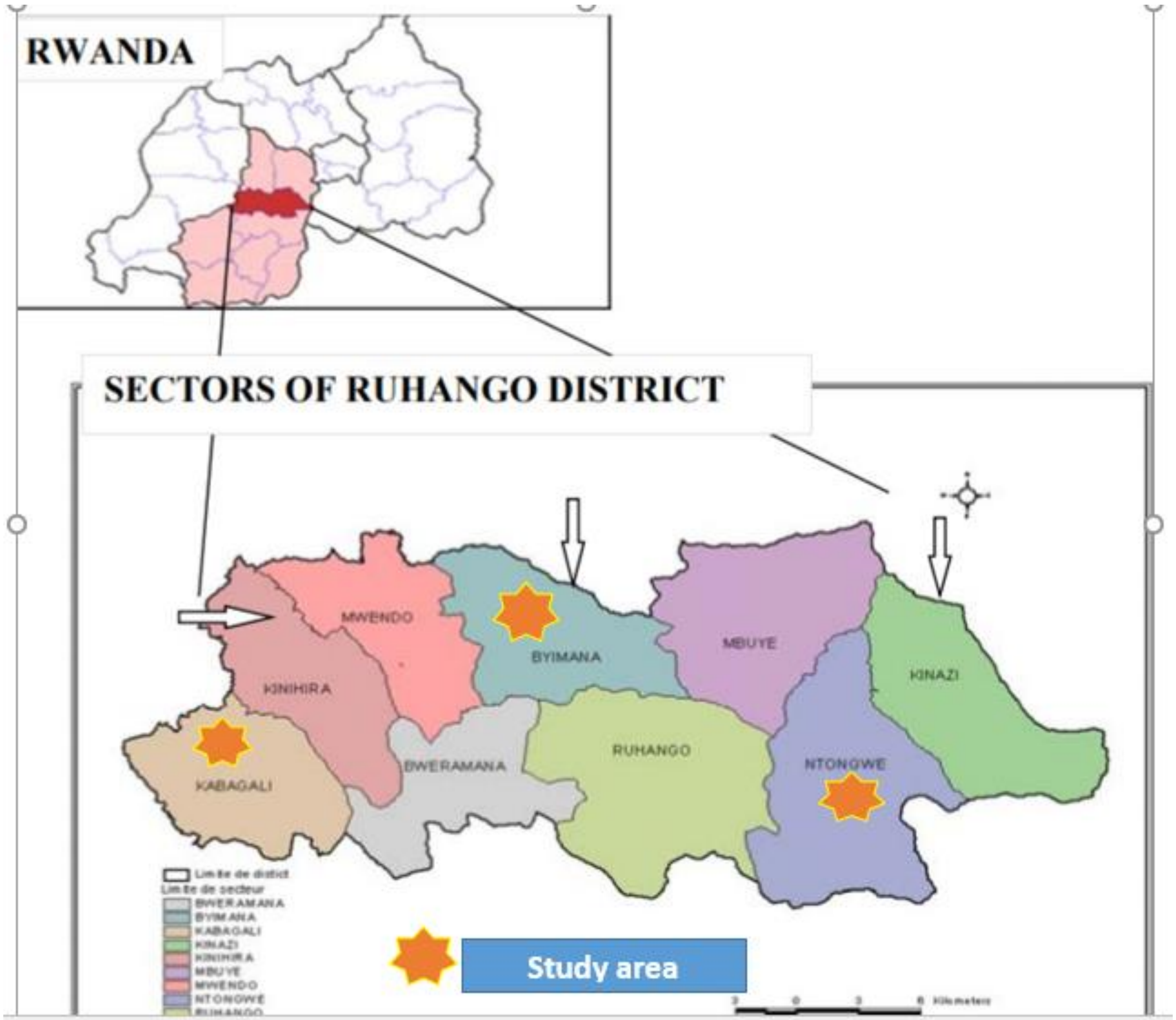

Figure 1: Ruhango district locations on Rwanda map

Source: https://twitter.com/ruhangodistrict/status/1239090042699571200 (2017)

3.1.1 Climate setting of Ruhango district

The average atmospheric temperature ranges to 15°C - 17°C in west highland region and the rain is abundant. In central, the temperature ranges between 19°C -21°C and the average rain fall of 1000 mm per year. In the East part of Ruhango district (Amayaga) rainfall is less irregular, that causes the severe droughts in this area and the temperature is higher and can go beyond 30°C during dry seasons.

Inter-Tropical Convergence zone which passes over Rwanda two time in year is the main synoptic feature which controlling rain seasons in Rwanda region (Sebaziga, 2014).

About 90% of Rwandan farmers have less than one hectare (1Ha) of land for agriculture, which is the main source of income for the Rwandan population and the people of Ruhango district. According to the EICV III, NISR, only 76 percent of the cultivated land in Ruhango district is covered from erosion using various methods. Improved seeds are purchased by 17.4 percent of agricultural households, organic fertilizers are purchased by 7.5 percent of agricultural households, and artificial fertilizers are purchased by 13.3 percent of agricultural households (Province & District, 2018).

Agriculture is one of the most vulnerable sectors in Rwanda to climate change and variability due to high reliance on rain feds and regular droughts and heavy rainfall affecting crops and limiting the capacity to adapt or cope with current climate stresses. A timely, accurate and reliable climate information service for farmers is one solution to building climate resilience in the field of agriculture. In vulnerable communities, short-term weather forecasts, seasonal forecasts and early warning systems may create reliable climate resilience (Ncoyini *et al*., 2022; ASSAR, 2015a).

3.1.2 Conceptual Framework

Access to and utilization of climate information systems are the first steps toward climate adaptation (CIS). Farmers are influenced by the CIS to make decisions on farm management and livelihood diversification in order to mitigate climate change and take advantage of favorable conditions. In this study the dependent variables were the climate communication channels whereas the smallholder farmers' socioeconomic characteristics are independent variables as illustrated in Figure 2 where the Rwanda Meteorology Agency provide forecasts to users through various dissemination channels which include television, radio, social media platforms, workshop, and through interaction with agricultural cooperatives. The various communication channels to disseminate climate information should have user-friendly features. End-users will be able to select suitable adaptation solutions from sources that are inexpensive, readily available, secure, credible, trusted, consistent, efficient, timely, and use understanding language.

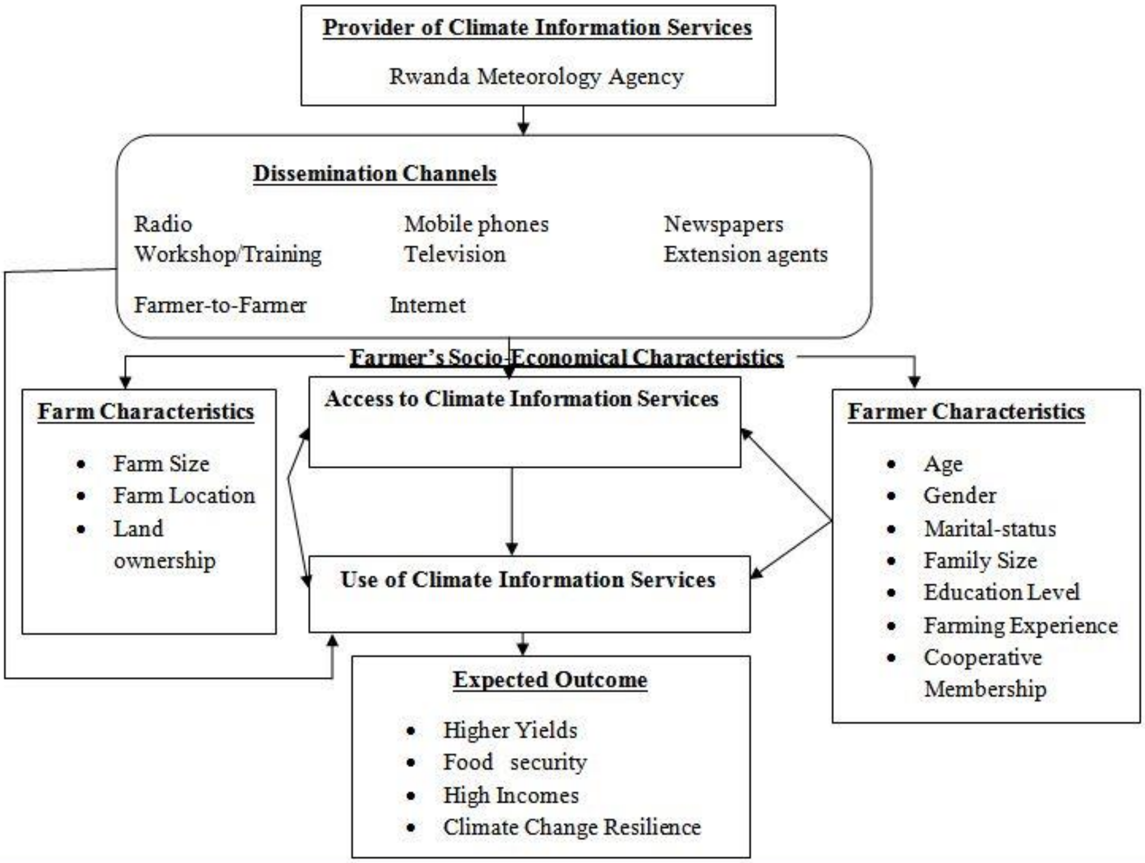

Figure 2: Conceptual framework demonstrating relations between different determinants of access to and use of climate information services Source: Author's conceptualization

Women' agricultural activities are often characterized by gaps in information and resource access, In several fields with shortcomings: property, labor, credit, knowledge, extension, and technology. Different levels of climate risk resistance and the impacts and discrepancies in decisions controlled by rural women and men have contributed to gender differences in the needs and preferences for climate information, potentially limiting women's capacity to benefit from climate services (Huyer *et al*., 2017). Some observational studies indicate that it is used by women who access sufficient climate information to improve their farm management activities, diversify crop production, and improve storage and processing techniques (Baffour-Ata *et al.*, 2022). The study conceptualizes that the social-economic characteristics of smallholder farmers determines the respondents' access to the climate communication services, awareness and accessibility to climate and weather forecasts and in turn influences the utilization of received information in farm management.

Their decisions are sometime based on their general understanding based on traditional climatic patterns for their regions. Increased frequency, the negative impacts of extreme weather events such as irregular precipitation, extremely severe droughts and failure to access climate information services through the climate communication channels promptly has compromised small holder farmers' productivity. However, smallholder farmers have the potential to accrue maximum benefits from accurate and timely climate and weather information services provided. If these farmers have access to climate information and use it to manage their farm, productivity would increase abundantly, and minimization of the negative impacts of climate change and variability.

3.2 Methods of Analyses

The study used primary data obtained through semi-structured questionnaire. The questionnaire was divided into four sections respectively in accordance with the research objectives. The study targeted smallholder farmers in the respective three purposely selected sectors of Ruhango District. Two research approaches namely Key Informant Interviews (KIIs) and smallholder farmers interview were used for data collection through use of semi-structured questionnaires which were developed and administered through face-to-face interview by using SurveyCTO (is based on the Open Data Kit /ODK and is the most reliable, secure, and salable mobile data collection platform for researchers and professionals) application installed in Tablets to record respondents' answers. After data entry and the data was presented using frequency tables, charts and graphs using the computer software Statistical Package for Social Scientists (SPSS) (Version 20)) and summarized into different categories.

3.2.1 Study Design and Sampling

The survey methodology was used to identify and assess the smallholder farmers' socio –economic characteristics which influence access to climate communication channels for informed decision-making. During survey, methods including face-to face interviews, Key Informant Interviews were performed and smallholder farmers (decision-makers), extension officers, and representatives of agricultural cooperatives were respondents concerned in survey interviews. The first sampling was purposively, Consideration of three agro-climatic zones based on the climatic regions of the country in accordance with the (Muhire *et al.*, 2015) , classified of the regions by topography of Rwanda.

The east province is where the altitude is between 1000 m and 1500 m, with annual precipitation between 740 and 1000 mm. The second zone is the central plateau at an altitude of between 1500 and 2000 m, with rainfall between 1100 and 1300 mm per year. The third area is the Congo-Nile Ridge highlands, with altitudes between 2000 and 4500 m and rainfall between 1300 and 1500 mm per annum.

The participants to be interviewed were determined on the basis of the formula by Sharon (1997) as shown in equation (1)

$$S = \frac{Z^2 * (P) * (1 - P)}{C^2} \dots\dots\dots\dots\dots\dots\dots\dots \text{ (1).}$$

Where

S= sample size

Z^2= abscission of normal curve $(1.96)^2$

C= desired level of precision

P= estimated proportion of an attribute that is present in the population

In Ruhango district, the percentage of population involved in agriculture was 90% (p=0.90)

In this study, the margin of error was 5% at the confidence level of 95%; In Ruhango district, the percentage of population involved in agriculture is 90% (p=0.90), so that the sample size, S was obtained thus

$$S = \frac{(1.96)^2 .(0.90).(1-0.90)}{0.05^2} = 138 \text{ farmers}$$

The 138 small holder farmers and 21 farmers to control the sampling errors (Population Specification Error, Selection Error, Sample Frame Error, Non-Response Error), one approach used to minimize those errors (sampling and non-sampling) is to increase the sample size (Qualtrics, 2021) In general, the sampling errors decrease as the sample size increases (Shalabh, 2021);(Lynn, 2021) . The total of a hundred and fifty-nine (159) respondents were selected purposively in three different sectors of Ruhango district. Respondents were selected purposively with the guidance of agro-cooperatives' leaders in three sectors of Ruhango district namely Ntongwe, Byimana, and Kabagari. 53 small-holder farmers in each sector were interviewed. In this study the farm decision-makers were targeted for survey's interview in order to minimize bias.

3.3 Data Collection and Analysis

The key data collected through interviews and standardized questionnaires were used in this study to obtain both primary data on socio-economic characteristics of smallholder farmers, access to and utilize of climate information services, and adaptation initiatives taken by smallholder farmers in the district of Ruhango. Key Informant Interviews (KII) was used through face-to-face interviews between researcher, extension officers and Meteo-Rwanda staff. The data generated from the questionnaire, and interview guide were sorted, arranged and coded for analysis by using of version 2.0 of the Social Sciences Statistical Package (SPSS) and qualitative data from interviews were organized for thematic content analysis. Quantitative methods like averages and percentages were also used and this involved the examination, categorization, tabulation and recombining of evidences to address the study objectives.

3.3. 1 The climate communication channels used by smallholder farmers in Ruhango district

The various CIS used by smallholder farmers, as well as the various communication channels used, were investigated for this objective. This was accomplished with the use of the Statistical Packages for Social Science (SPSS) applications, with the findings summarized using percentages and frequencies.

3.3.2 The smallholder farmers' socioeconomic characteristics that influence the accessibility of climate communication channels in Ruhango district

The second objective was to examine the small holder farmers' socioeconomic characteristics that influence the accessibility of climate communication channels in Ruhango District. The findings were displayed in a Table format using a multiple linear regression model in the Statistical Packages of Social Science (SPSS) tools. This provided the basis for the inclusion in this research of the socio-economic variables. As a dependent variable (X), climate information services were used, while ten socioeconomic characteristics of the participants were used, namely gender, age, marital status, level of education, household size, socioeconomic category (Ubudehe), farm size, farming experience, other source of income, and cooperative membership; The independent variables (CIS communication channels) were used as (Y).

As shown in Equation (2) below, the implicit regression model was:

$$Y = \beta_1 gender + \beta_2 age + \beta_3 marital\text{-}status + \beta_4 educacation\ level + \beta_5 household\ size + \beta 6_{Ubudehe}\ cat. + \beta_7\ Farmland\ size + e \ldots\ldots\ldots\ldots \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where;

Y = Climate information services channels

X_1 = Gender of farmer

X_2 = Age of the farmer (years)

X_3 = Marital status (single, married and widowed)

X_4 = Educational level (no formal education, primary, secondary, tertiary)

X_5 = Household size (number of persons)

X_6 = Socioeconomic category (UBUDEHE)

X_7 = Farm size (ha)

X8 = Farming experience (Years)

X9 = Other source of livelihood other than agriculture

X10 = Agro-cooperative membership

e = Error Term; where it is assumed that the error terms are independent and usually distributed with mean zero and equal variance. The error term accounts for the variation in the dependent variable that the independent variables do not explain. Random chances should determine the values of the error term. For your model to be unbiased the average value of the error term must equal zero.

The following preliminary test was performed on the data with running a multiple regression analysis:

Multi-collinearity - There may be a correlation between two or more independent variables. Collinearity is the term for this situation. Multicollinearity is an unusual condition in which collinearity occurs between three or more variables despite the fact that no pair of variables has an especially high correlation. When multicollinearity is present, the regression model becomes unreliable. Multicollinearity was assessed in this study by calculating a score known as the variance inflation factor (VIF), which calculates how much the variance of a regression coefficient is exaggerated due to multicollinearity in the model. VIF has the lowest possible value of one (absence of multicollinearity).

A VIF value greater than 5 or 10 shows a significant amount of collinearity, as a rule of thumb (Passi et al., 2013).

3.3.3 Factors that hinder the use of the available CIS by smallholder farmers in Ruhango district

This objective analyzed the responses on questions about why the smallholder farmers aren't using climate information for informed decision-making in farm management as responded by agro-cooperatives' leaders and the agricultural extension officers. The Statistical Packages of Social Science (SPSS) software has been used to accomplish this. And the results use of summarized by percentages and frequencies. These results were presented using Tables and Graphs to show the main factors hindering the smallholder farmers to use of CIS.

3.3.4 The available adaptation practices applied by smallholder farmers to tackle the effects of climate change in Ruhango district

This objective analyzed the responses on questions asked about adaptation practices adopted by smallholder farmers to tackle the threat of climate change in their region. The Statistical Packages of Social Science (SPSS) software has been used to accomplish this through importing primary data from excel sheet and the results use of summarized by percentages and frequencies. These findings were illustrated in the form of tables and graphs to demonstrate the key factors influencing smallholder farmers' use of CIS.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the study findings based on the data gathered and analyzed from the field. Five sections discuss the findings. The results of the background information of the respondents are discussed in section 4.1. The other four sections describe the findings of the analysis based on the goals of the study as follows; The outcome of the channel(s) accessed by smallholder farmers is presented in section 4.2. while section 4.3 presents the results regarding the relationship between the socioeconomic characteristics of smallholder farmers and access to climate information. Section 4.4 presents results of factors of lack of use climate information in decision making. Section 4.5 reports on the results of the adaptation practices adopted by smallholder farmers of Ruhango district.

4.1 Demographic and Socioeconomic characteristics of smallholder farmers

This sub-section highlights household demographic and socio-economic characteristics that play an important role in agricultural production, such as gender, age, size of the household, marital status, level of education, experience in agriculture, other means of revenue, socio-economic category and size of the farm. One hundred and fifty-nine (159) smallholder farmers from the three sectors, namely, Byimana, Ntongwe and Kabagari of Ruhango district were involved in the study.

(i) Age and gender of the smallholder farmers interviewed

The age ranges of the farm households ranged from 20 to 82 years old, with a mean of 44.45 years and a standard deviation of 13.78. As a result, the majority of smallholders in Ruhango are elderly.

Table 1: Distribution of age of respondents

Variable	Mean	Standard deviation	Minimum	Maximum
Age of respondents	44.45	13.78	20	82

Source: Field survey, 2018

These findings are similar to those of (Byishimo, 2018) who found that the overall mean and standard deviation of age of small-farmers in the districts of Bugesera, Gicumbi, Nyabihu and Nyamagabe were 44 years and 14.05 respectively, and the age range was between 23-84.

From this study, most smallholder farmers in Ruhango district were old and thus indicating limited involvement of youth in agriculture sector.

A study in Senegal showed that information must be communicated to women and other socially disadvantaged groups through specific networks to which they have access to, such as water boreholes and market points. The analysis showed that efficient communication networks are extremely context-specific and differ from community to another. The project's responsiveness to these specific communication channels has seen a highly substantial rise in the number of community members who have recorded access to information, from a few to 100%. In terms of access to climate information services, there were significant differences between men and women. The rural men, especially in afternoon, meet in bars where it is easy to get up-to-date information, that's when women stay home and take care of the children and household chores. Indeed, men have more access to almost all related climate information and services than women (Diouf et al., 2019). Younger women as well as young people in general have a higher chance of using modern technology to access information than uneducated, poor old women. Age is significantly determinant for women with a significance amount of 5% and not significantly determinant for men. Farmers who are optimistic in the utility of CIS have a higher tendency to use climate information. Furthermore, for men in particular, engaging in supplementary practices such as small business, transportation, and adaptation strategies can have a huge impact on their chances of access to climate information services (Diouf *et al*., 2019).

Studies have also shown that the types of climate information needed by farmers based on gender: women planted after a month, while men planted on time. At the beginning of the season, women were then less able to plant as they had less access to productive assets, such as natural fertilizers and other inputs as this had the greatest effect on their output (Sandner, 2012) .

(ii) Household size

The total number of household members living in the same house and having all privileges in household matters was described as the household size.

The results of this report indicate that, according to EICV4, the average household size of 4.8 people per household is significantly higher to the national average of 4.6 people per household (Byishimo, 2018) report released by NISR.

The size of a household has a strong relationship with climate change adaptation efforts (Mwalusepo & S Massawe, 2015) . This implies that family with larger number of members have higher demand for CIS. This is because as the number of productive participants grows, more labor becomes affordable, increasing the probability of using climate information services.

Table 2: Average household size

Variable	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Household size	4.82	1.8	1	9

Source: Field survey, 2018

Alternatively, the probability of uptake and utilization of climate information may also be decreased by growing the number of family members as additional active family members seek off-farm jobs that minimize over-dependence on agricultural livelihoods (Tumbo *et al.*, 2018).

(iii) Marital status of smallholder farmer

The findings given in Table 3 show that 67.9% of the smallholder farmers surveyed are married. This category is argued to be the most powerful persons and policy leaders at all stages (Byishimo, 2018). The 18.2 percent of smallholder farmers surveyed, were widows. As most smallholder farmers in Ruhango district are married, they are benefiting from increasing production levels and efficient climate change and variability adaptation's measures than other smallholder farmers (unmarried, widowed and separated), since they shared ideas on their agricultural practices.

Table 3: Marital status of the household head

Marital Status	**Frequency**	**Percentage**
Single	19	11.9
Married	108	67.9
Widowed	29	18.2
Divorced	2	1.3
Separated	1	0.6

Source: Field survey, 2018

(iv) Education level of the smallholder farmers

The total number of years of formal education of smallholder farmers is seen in Table 4 below. The findings show that out of 159 farmers, 142 reported attending formal education. The average number of years is roughly 6 years of primary education.

(Byishimo, 2018) reported that the level of literacy of small holdings increases the likelihood of adaptation to climate change. It has been found that farmers with more literacy are much more likely access to and use of climate information services than farmers with lower education level and to adopt to climate change-related adaptation practices.

In addition, increased levels of education among farmers have contributed increased access to and use of climate information services in their farming operations (Komba & Muchapondwa, 2012).

Table 4: Smallholder farmers' education level

Education Level	Frequency	Percentage
Primary school	103	64.8
Secondary school	24	15.1
University/ College	15	9.4
No form of informal education level	17	10.7

Source: Field survey, 2018

The highest education level of respondents was college degree holders who constituted 9.4% of the respondents; the 17 respondents (10.7%) were no form of informal education. The more respondents (64.8%) have only attended the primary education while 24 (15.1%) respondents had attended secondary schools.

(v) Alternative livelihoods

Table 5: Alternative livelihoods

Do you have another livelihood from agriculture?	Frequency	Percentage
Yes	58	36.5
No	101	63.5

Source: Field survey, 2018

More than 63.5% of the total small households in the district of Ruhango were engaged in agriculture alone, while 36.5% of them combined it with other activities as alternative livelihoods. Agriculture has been the main source of income for a considerable portion of the population. This emphasizes the role of the agricultural sector in terms of food security, the rural poverty reduction and other ways of managing the social pressure of economic changes and restructuring. At the same time, since agriculture remains one of the primary sources of revenue for most smallholder farmers in Ruhango district, this also means that many people's livelihoods have become increasingly vulnerable to actual and future climate stresses that have a direct effect on crop yields.

(vi) Farming experience

(Guido et al., 2020) argued that farming experience is a good indicator of age. Older farmers are less likely to check out information and news and, as a result, less depend on a variety of sources of information. This means that the older the farmer, the lower the yield, which may be attributed to a reduction in the physical capital needed to engage in agricultural operations. As presented in Table 1 above the majority of smallholder farmers in Ruhango district were old which can be an indication of low agriculture production. In other hand, farming experience is beneficial to increasing efficiency because it promotes fast introduction of new technologies. In this study the minimum and maximum were 2 and 60 years respectively while the mean was about 25 years. The Figure 3 below shows that 35.4% of smallholder farmers in Ruhango district had above 25 years of experience in agriculture sector.

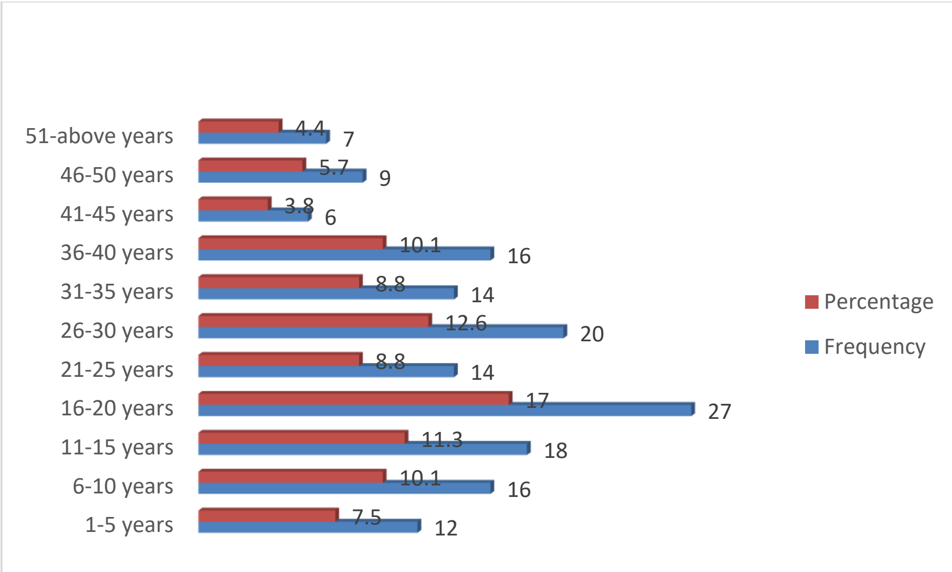

Figure 3: Farming experience of smallholder farmers
Source: Field survey, 2018

(vii) Farming land size

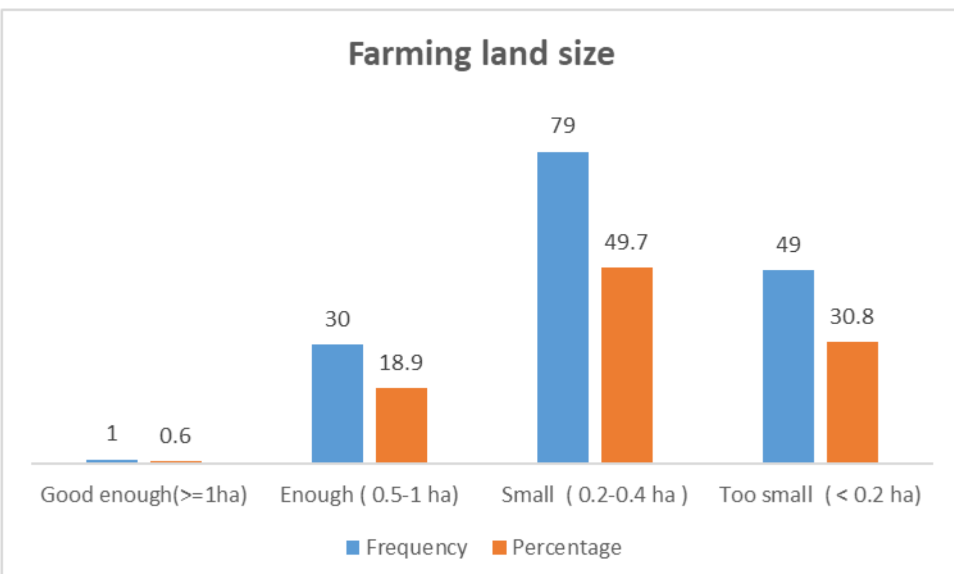

Figure 4: Farmland size
Source: Field survey, 2018

The world's poorest population are landless in general. In a given land, the relationship between food security and household development is primarily relevant to smallholder farmers (Hiwot Yirgu Astemir, 2014). From Figure 4, the results have shown us that majority (49.7%) of smallholder farmers in Ruhango district having the small farmland which can contribute to their high vulnerability on climate risks in their area because they can't diversify cropping system and can't alternating the farms' location (e.g. from wetland to high land when flash flooding is forecasted and vice-à-versa during the dry season).

Farmland size is very important factor for adaptation to climate change. Families with farm lands are able to conduct farming and disperse climate-related disruptions because they own large farms, Farmers with large farms will have a high chance of receiving and using climate information in their farming decision-making (ASSAR, 2015b).

4.1.2 Access to climate information services by smallholder farmers in the Ruhango

The first objective analyzed various climate information and its dissemination or communication channels accessed by smallholder farmers of Ruhango district. The findings were summarized using frequencies and percentages, and presented using tables and graphs to display the most commonly utilized CIS channels

On the small holder farmers' awareness of climate information services issued by Meteo-Rwanda, 92.5% of those interviewed indicated that they were aware about Rwanda Meteorology Agency. The climate information issued by Meteo-Rwanda include daily weather forecasts, five days' weather forecasts, ten days' weather forecasts and season forecasts as reported by Meteo-Rwanda interviewed staff. But access of those products was not effective where only daily weather forecast have received by 91.2% whereas only 1.3% of farmers had received five days' weather forecasts, 0.6% received the season forecasts, while 100% of all interviewed have never received ten days and warning forecasts on heavy rainfall. Lack of accurate climate information services for smallholder farmers can be attributed to a number of factors that have a significant impact on information

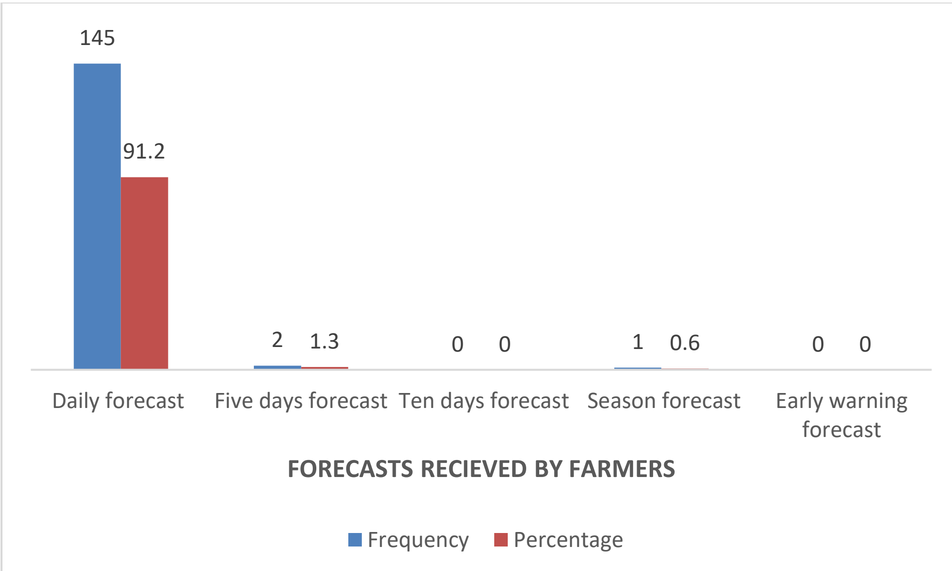

Figure 5: Level of awareness of the climate information services offered by Rwanda Meteorology Agency

Source: Field survey, 2018

Figure 6 below the results has shown that only (25.8%) of smallholder farmers were received the climate information daily, while others (74.2%) were not. The main reasons as said by farmers themselves are: (i) most of them said that they accessed daily forecasts through radio channels the most of time the radio broadcasting weather forecast information at time when the smallholder farmers went to farm or when are busy in domestic activities like cooking.

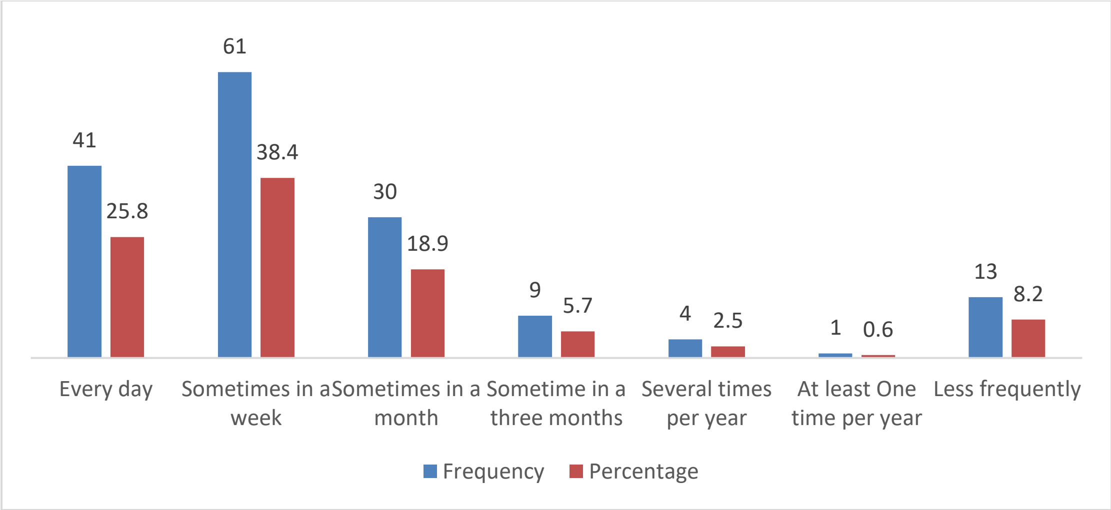

Figure 6: Frequency and percentage of how often obtaining CIS
Source: Field survey, 2018

4.1.3 Climate communication channels accessed by smallholder farmers

Results in Figure 7 give the various channels of climate information services in which the smallholder farmers are able to receive the climate information services.

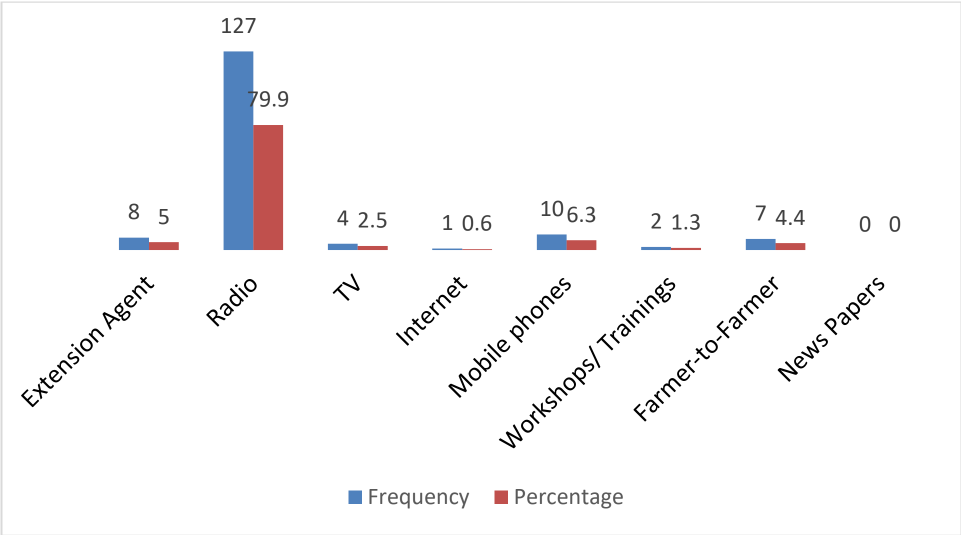

Figure 7: Climate communication channels accessed by Smallholder farmers
Source: Field survey, 2018

The results show that most (79.9%) received climate information services through radio(s), the mobile phone was the second channel accessed by 6.3% of respondents. By ranking of climate information channels, While the internet was the first tool used by Rwanda Meteorology Agency to disseminate CIS, said by interviewed Meteo Rwanda staff; Table 7 show that the Internet was not accessed by most of smallholder farmers (0.6%) which can justify the poor access of climate information and services among them.

Because of the good radio waves and many radio stations widely scattered around the country, radio was ranked first. 'The radio stations are often available at reasonably low cost, so many farmers can afford to purchase and own a radio as well as access the radios' news via mobile telephones. And radio listening through cell phones owned by most of the people of Rwanda is relatively easy. This finding verified the outcome of a study carried out in all the provinces of Rwanda, where radio seemed to be the key channel of communication for climate information in all the provinces of Rwanda, as confirmed by 74 percent of respondents (Jeanne Y Coulibaly *et al*., 2017).

Radio has become the most used medium of communication between local agricultural and pastoral populations in Africa and Asia, where (Churi *et al*., 2012) Climate information services are stated to be transmitted predominantly by radio and cell phones. The most widely used communication medium is radio because its transmitted signals reach to wider range of people and because the vast majority of agricultural and pastoral groups possess or have access to radio (McGahey & Lumosi, 2018).

The mobile phone is the second important climate communication channel. When providing information between climate service suppliers, farm workers and extension agents, mobile phones could be among the simplest ways of using them. This creates a sense of one-to-one interaction from each element to find solutions in a shorter time. The mobile service providers found in Rwanda included MTN, and Airtel-Tigo. The expansion of the mobile phone facilities and the expanding number of services offered by phone companies have been mentioned as a justification why the number of customers that use the tool for information communication has increased. Many smallholders and extension agents owned mobile phones that they are using when seeking climate and other agricultural information services (Tumbo *et al.*, 2018).

In India the majority of agriculture information systems based on cell phones have failed to perform efficiently or satisfy the needs of farmers. Regardless of the fact that farmers obtain information from these sources, they receive no additional benefit from it as compared to information obtained from conventional sources. Regardless of their location or crops type, farmers need the same general categories of knowledge. The messages sent, on the other hand, should be focused on farmers' knowledge needs so that they can use it in their everyday agricultural activities. To produce locally appropriate information that farmers need, a deeper understanding of the farmer's local background is needed (Mittal & Mehar, 2016).

The distribution of climate information must be scheduled to fit with the farmer's cropping cycle, but it must also be backed up by daily specifics of any of these events and the steps that must be taken. For example, information on variety selection must be delivered just before the farming season. The supply of information at the right time (giving the farmer enough information to make an informed choice) is critical. Farmers received warnings from SMS telecom operators about rust traces found in a few fields and were urged to take the necessary precautions. Farmers who are linked to the SMS service can be able to take immediate action to save their farm. The information sent by text message or voice message on a cell phone must be tailored to the preferences of the targeted consumers. Getting text messages would not inspire farmers to start using this information or applying the recommendations. Farmers must be made aware of the benefits of this quicker mode of communication and how it will benefit them (Mittal & Mehar, 2016).

Farmers' demands are diverse and will, so the climate service should be able to satisfy them. At the village level, an assessment of the farmer's relevant knowledge should be made, and continual appraisal of needs should be integrated into the communication framework. This will assist service providers in keeping track of farmers' current socioeconomic status as well as demand and capacity issues. The users of mobile phones have easy access to climate information. Farmers and extension staff also use cell phones to share information, which is beneficial to all parties in enhancing agricultural operations.

4.2 Determinants of smallholder farmers' socioeconomic characteristics that influence the access to climate information services channels

The age of the farmer (AGE) is estimated by measuring the respondent's age in years at the time of data collection by the number of years he or she has lived. Older farmers are less likely to check out information and news and, as a result, less depend on a variety of sources of information. Education is one of the most important considerations in a farmer's decision to consider the risks associated with new technologies and existing information sources. Farmers with a higher level of education are more likely to embrace emerging technologies faster and make more use of advanced inputs during the implementation process (Mittal & Mehar, 2016).

Table 6: Multiple regression estimates of factors affecting access of CIS communication channels

Independent variables	Unstandardized Coefficients		Standardized Coefficients	T	p-value	Collinearity Statistics	
	B	**Std. Error**	**Beta**				
(Constant)	3.426	0.422		8.124	0.000		
Family size	-0.491	0.229	-0.175	-2.143	0.034	0.943	1.060
Gender	0.201	0.259	0.065	0.776	0.439	0.886	1.128
Age	-0.471	0.345	-0.155	-1.362	0.175	0.486	2.057
Marital status	0.331	0.245	0.132	1.354	0.178	0.658	1.520
Social-economical Categories	-0.132	0.199	-0.056	-0.662	0.509	0.876	1.142
Education level	0.136	0.126	0.092	1.078	0.283	0.863	1.159
Other source of income	-0.138	0.264	-0.044	-0.521	0.603	0.894	1.119
Farm size	-0.186	0.174	-0.087	-1.069	0.287	0.936	1.068
Farming Experience	0.087	0.227	0.045	0.385	0.701	0.458	2.185
Coop. Membership	0.017	0.261	0.005	0.065	0.948	0.978	1.022

*Significant at $P < 0.05$
Source: Field survey, 2018

Multiple linear regressions were used to assess the impact of smallholders' socio-economic factors (independent variables) to access climate communication channels (dependent variable) in Table 6. The Tolerance and collinearity with Variance Inflation Factors (VIF) values greater than 0.1

and not greater than 10 respectively, therefore, mean there were no multi-collinearity levels (Kim, 2019) . In this study the climate information communication channels accessed by smallholder farmers are used as dependent variables;

whereas the independent variables are different socioeconomic characteristics of the farmers. Table 6 reveals the relative contribution of the dependent variable, socioeconomic characteristics (age, gender, marital status educational level, farm size, family size, farming experience, other source of income, Socioeconomic categories and cooperative membership) to the independent variable, (climate information communication channels). The table shows the results, expressed as by P-value as follows: Family size ($p_v = 0.034$), Age ($p_v = 0.175$), Gender ($p_v = 0.439$), Marital status ($p_v = 0.178$), Educational level ($p_v = 0.283$), farming experience ($p_v = 0.701$), socioeconomic categories ($p_v = 0.509$), Cooperative membership ($p_v = 0.948$) and farmland size ($p_v = 0.287$).

The results show that almost all socio-economic characteristics (age, gender, farmland size, educational level, farming experience, socio-economic categories (Ubudehe), cooperative membership and other source of income of smallholder farmers were not statistically significant. However, this study suggests that the access of climate information services communication channels is the same and hence policies developed for CIS communication channels or dissemination should take into account the socio-economic differences of all smallholder farmers to ensure effectiveness in accessing to and using of climate information services in their informed decision-making for farming. Only family size (Pv=0.034) was statistically significate to influence the access of climate communication channels. The size of a household has a positive relationship with climate change adaptation efforts (Mwalusepo & S Massawe, 2015). This implies that family with larger number of members have higher demand for CIS. This is because as the number of productive participant's increases, more labor becomes affordable, increasing the probability of using climate information services. (Muema, 2018) discovered that adding one person of a household raised the likelihood of accessing climate information resources by 2.8 percent. This meant that families with more participants had a better chance of using a variety of climate information resources. And it was discovered that families with more members were more likely to respond to climate change, resulting in a greater demand for climate change adaptation products.

The research conducted in Kenya, (Mburu, 2013) results has shown that farmers claimed that radio was a low-cost way of accessing information, and many of them own one. Owing to the higher cost of a television than a radio, many farmers did not buy one. Farmers over the age of 40 tended to listen to the radio for agricultural information, as opposed to farmers under the age of 40.

The majority of farmers, including those without electricity, possessed a radio and powered it with batteries. They said that, unlike television, the radio uses words that are clear and easy to understand. More than 90% of farmers who own a cellphone use it to communicate with friends, send and receive money, but not to obtain agricultural information. Since it is costly to purchase and operate their own computers, some farmers with university and college education and those under the age of 40 use their cell phones and the internet in cyber cafes to search for agricultural information. They, on the other hand, talked about power outages as a barrier to using computers to access information. Simultaneously, they liked the computer because it allowed them to download information to other computers, browse the internet at their leisure, and monitor their information needs and selection. Small- farmers who claimed to have followed the technology obtained through the channels claimed that the end results had improved.

4.3 Factors for lack of use of climate information in decision-making

Climate information is widely used for crop season preparation and strategic decisions such as crop selection, variety, planting date, overall irrigation systems requirement and others; climate information is also used for operations such as the exact planting date depending on soil moisture content, whether to apply, estimate harvesting (in the case of rainfall forecasts) Application of irrigation as well as others. Farmers use climate information services in timing different farm operations like land preparation, planting, weeding, in pest and disease control, harvesting and other important decisions like selection of seed varieties to be planted in a season in their agro-climate region (Watkiss *et al*., 2019). The findings in Table 7 reveal that only 11.9 percent used the climate information obtained and forecasts throughout the decision-making of their farm-related operations.

Table 7: The use of CISs in Ruhango district by smallholder farmers

Use of climate information	Frequency	%
Not used	140	88.1
Used	19	11.9

Source: Field survey, 2018

Factors responsible for not using climate information services by smallholder farmers in Ruhango district

Factor 1: Unreliable and untimely climate information services

In Rwanda, weather forecasts were given on daily, five and ten days, and season basis with non-exact rainy dates on spatial aspect, intensity and end of rainy season but only above normal, near normal and below normal weather conditions are issued. Such content of the weather forecast information given to smallholder farmers is inadequate and the usefulness in their farming decision making is limited.

Rwanda Meteorological Agency provided weather outlook for the region to all districts once in rainy season period. However, there was absence of weather forecast outlook updates as a result complicating the understanding of abrupt weather pattern changes that occurs in the seasonal for both extension officers and farmers. This affects the strategy to adapt to the uncertainties surrounding farming activities as reported by all three sector's extension officers during the key informant interviews.

(Amadi & Chigbu, 2014) have indicated that accurate and timely information on the weather and climate is an important component for countries' socio-economic growth. It is vital to building a mechanism that translates information into recommended actions (e.g. notifications, warnings, emergency) and eventually delivers the information is imperative " Decisions depend not on the accuracy and availability of information, but on the ways that individuals take action, how they interpret information, and how options are evaluated" (Leung & Vail, 2016) . Observation made that "many policies failed because experts agree that improved information would immediately lead to better decisions without fully knowing the real situation and the operational context in which climate information should be used. "The provision of specific information is limited by the constraints on location-specific forecasts of the current global modeling systems" (Watkiss *et al*., 2019) .

Factor 2: Poor communication process of climate information services

The provision of adequate, reliable and accurate weather forecast information supported by regular forecast outlooks can improve on pre-farming decision making. This shall avert the incidences of weather abrupt change impacts.

The 100% of extension officers said that “untimely dissemination and inadequate content of the seasonal forecast given to the climate information and services users”. The poor level of accuracy and inconsistency in dissemination of weather forecast led to farmer’s loss of trust and confidence in climate information and services. However, the dissemination was sometimes issued in the middle of the rainy seasonal. The limited time given for agricultural extension officers to interpret and reach the farmers before they start their farming operations makes them ignore the information and not forwarded the forecast to farmers. Time preference for receiving different types of climate information (rainfall duration, rainfall amount, seasonal onset and cessation) at least one month earlier (extension officers suggested).

First and foremost, CIS should be made available to farmers in influencing their farming decisions. However, there was no provision of agro-meteorological information to direct farmers in decision-making. In contrast to the foregoing, when such information or services are available, users frequently find it difficult to interpret them in order to influence farm-based decisions. This has been the main major obstacle to the application of CIS in policymaking. This conclusion is in line with that of (Naab *et al*., 2019) whose research revealed smallholder farmers' inability to comprehend climate information to make sense of forecasts in Ghana is attributed to the mode of transmission of such information. And That study showed that there is a lack of cooperation in the development and distribution of usable climate information in Ghana's agriculture sector. Unlike other industries, agriculture is one that necessitates what describes as a ‘best fit’ between the knowledge, institutions and the users in service production.

This shows the critical point in farming when a specific type of climate information is needed to help the smallholder plan and implement farming activities appropriately. For example, knowing the duration and relative amount of rainfall in the crop season helps the smallholder identify what type and variety of crops to plant and when to weed. Timeliness of climate-related information is very important to the progress of farmers, the extension agents added.

Information should be issued to farmers at the right time to apply this information to their farming practices in order to maximize farm productivity (Bouroncle *et al*., 2019). It has been shown that the timely access to information is important for the efficient execution of planning and budgeting, coordination, management. farmers need timely information to be able to schedule activities to be carried out according to the situation encountered. Timely information about precipitation, for example, would help them prepare for the time they need to start preparing their farms. This information would also help them understand of the types of seeds to be grown, based on the rainfall patterns, since many of these farmers rely on rain-fed agriculture. Extension agents have pointed to the miscommunication, coordination and partnership between agencies and organizations participating in the development and distribution of climate information, leading to a lack of trust and a lack of willingness to access to climate information.

(Ongoma & Shilenje, 2016) mentioned that "The lack of a robust user profile has contributed to a substantial difference between the information that is likely to be useful to farmers and that produced". (Okoro *et al.,* 2016) said that when there is reciprocal involvement in the communication process and the communicator's capacity to have communication abilities, effective communication may take place. When variations of teaching methods are used in information sharing, farmers learn more. Communication should not just be the exchanging of information, but should be an engaging and participative process in which talking and listening should be exchanged (Churi *et al*., 2012); (Amegnaglo *et al*., 2017) .

The results of the study suggest that a farmer's age, level of schooling, and farm scale all have an impact on how they use different sources of information. Farmers use a variety of information sources, some of which may be complimentary or substitutes for one another, meaning that no single source can satisfy all of a farmer's information needs. We will provide guidance and create strategies to provide information from certain channels in specific functional groups with the most successful impact if we consider the possibility of farmers' choice of information source.

Originality/Value: Information is essential in a farmer's life because it improves their understanding and helps them make better decisions (Mittal & Mehar, 2016). (Stone & Meinke, 2006); (Buontempo *et al*., 2014) suggested six reasons that limit farmers' use of climate information, along with recommendations on how to address them in (Table 8) below.

Table 8: Factors limiting farmers' use of climate and weather forecasts

	Causes	**Effects**	**Corrective action**
Credibility	Previous forecasts are seen as "false," and the communicator is not widely regarded as trustworthy.	Forecasts would be ignored by farmers.	Make probabilistic forecasting and focus on reliable communicators.
Legitimacy	Farmers' regional experience is thought to be superseded by forecasts.	Farmers would dismiss forecasts and any guidance that comes with them.	Make an effort to integrate local knowledge into the forecast, and farmers should be involved in the development of advice information.
Scale	Forecasts don't tell you much about what's going on in your area.	Forecasts would not be used by farmers in their decision-making.	It is necessary to collaborate with farmers in order to assess the consequences for the local region.
Procedures	Forecasts that are made at the inappropriate time, to the wrong individuals, or are unexpected	Forecasts would not be taken into account by farmers.	Communication should be repeated to overcome the timeline, as well as the presence of relevant main players.
Choices	Forecast does not have sufficient evidence to make any particular decision.	Farmers are unlikely to alter their plans in answer to a forecast.	Farmers must develop their forecasting skills and be encouraged to make incremental choices.
Cognition	Forecasts have a new format that is confusing and exclusive.	Farmers can either ignore forecasts or use them in an ineffective manner.	Need to consult with farmers on a regular basis to decode the significance of forecasts for their area and correct errors.

Source: (Patt & Gwata 2002)

4.4 Adaptation practices used by smallholder farmers in Ruhango district

The fourth objective was aimed at investigating actual adaptation practices at the farm level, as well as the factors that appear to be driving them. Based on the experience of farmers in the Ruhango district, this objective intends to capture the extent to which of farmers' perceptions of climate change, and the types of adjustments they used in their farming practices to tackle climate related chocks in their area. Farmers were asked if in recent years they had faced effects related to climate change. Questions about often adaptation practices they implemented in their area and limitations associated with climate adaptation were asked.

100% of smallholder farmers were confirmed that climate has changed especially for rain fall pattern. Changes in rainfall and temperature, as well as severe weather events such as droughts and floods, are likely to impact crop yields, in the following ways:

i. Temperature increases may affect the duration of the planting season;
ii. Based on their frequency and severity, likely variations in rainfall onset or cessation dates of rainy seasons influence the production of crops according to their timing and severity;
iii. Destruction of natural resources, such as a reduction in soil productivity due to soil erosion, has a direct effect on crop productivity;
iv. Increased occurrence of plants, pests and diseases, thereby requiring increased use of pesticides and herbicides, which can contribute to other unexpected impacts on the ecosystem both on the sprayed site and off-site, especially on water resources;
v. Adverse weather conditions, such as extreme rains, lead to crop failure by water logging, while droughts disrupt agricultural productivity due to water stress.

Any opportunities for improving food security and livelihoods need a deeper understanding of the multidisciplinary nature and creativity of the factors affecting food security and the effects of agricultural productivity. In addition, efforts to promote agricultural production, particularly in rain-fed conditions, need to incorporate risks and uncertainty, often linked to climate changes of weather.

(Rarieya & Fortun, 2015) noted that in an area where severe weather events have a direct effect on agricultural and human livelihoods, there would be a need for better delivery of weather information and incredible modes of teamwork between multiple experts from different scientific disciplines, institutions, sectors and resources.

The majority of farmers interviewed (99.4%) rely on rain-fed agriculture for their livelihoods, which makes them more vulnerable to climate change. The consequences of climate change and fluctuations experienced in the Ruhango district are seen in Table 9 below.

Table 9 Climate shocks experienced by smallholder farmers in Ruhango district

Climate chocks	**Respondents (Yes)**	**%**
Climate has changed?	159	100
Drought	133	83.6
Erratic Rainfall	158	99.4
Emergence of new disease and pests	150	94.3
Increase in landslide	42	26.4
Increase in Floods	108	67.9
Shifting in Rainy seasonal	117	73.3

Source: Field survey, 2018

Plate 1: heavy rainfall flooded and destroyed farms in east region of Ruhango district (May 2018)

Source: *Field survey, 2018*

For instance, adaptations at the farm level maybe either short or long term. The short-term adaptations could include practices such as changing the planting and harvest time, or using different kinds of inputs. Long-term adaptation, on the other hand, can involve improvements to land and water management methods, selection of cropping systems, procurement of crop insurance and diversification of operational farming (AGRA, 2014).

Table 10 below shows that the available adaptation practices applied by smallholder farmers of Ruhango district and only anti-erosion practices adopted by 53.5% of smallholder farmers while other practices are poorly applied (< 50%). The fact that many smallholder farmers are illiterate, together with ignorance/insufficient awareness of the impacts of climate change, leaves rural farmers extremely vulnerable to the complexities of changing climate and (Tumbo *et al*., 2018) estimated that poor and desperate farmers would likely divert their small farm income to food and medicine rather than investing in climate change mitigation and adaptation programs.

Table 10: Adaptation practices applied by small holder farmers

Adaptation Practices	**No. of Respondents (Yes)**	**%**
Plant Climate-Tolerant Varieties	39	24.5
Irrigation	57	35.8
Use of Pesticides and Fertilizers	63	39.6
Change of Farming Location	27	17.0
Erosion Control Practices	85	53.5
Agro-Forestry	27	17.0

Source: *Field survey, 2018*

Table 11 shows that the insufficient financial incomes or resources, lower appropriate adaptation techniques awareness, and unreliable and poor distribution of climate information services were reported as main constraints for effective adaptation to climate impacts in Ruhango district. Farmers' adaptation choices can be divided into two categories: a) improved diversification, and b) maintaining vulnerable growth stages by controlling the crops so that these crucial stages do not overlap with extremely harsh weather conditions, such as midseason drought conditions.

The following are several measures that can be used as a form of insurance regarding extreme rainfall: increasing diversification by planting water shortage and/or temperature-resistant crops; allowing effective use of available water; and growing a variety of crops on same plot or even on different plots, thereby reducing the probability of total crop failure because different crops are influenced differently by weather patterns. These methods may also be used to change the duration of the growing season, for example, by using drainage and water management approaches to supplement the water supply (Schlenker *et al.*, 2010)

Table 11: Constraints for adaptation practices of small holder farmers

Nature of constraint	**No. of Respondents (Yes)**	**%**
Untimely climate information / dissemination	113	71.1
Unreliable climate information	130	81.8
Insufficiency of resources	132	83.0
Don’t know what to do	28	17.6

Source: *Field survey, 2018*

Climate change is occurring, and attempts to eliminate greenhouse gas sources or increase sinks would take time. As a result, adaptation is crucial and a source of concern in developing countries, especially in Africa, where vulnerability is high due to a lack of capacity to adapt. Climate change is projected to have an impact on food and water supplies in Africa, where many people, especially the poor, depend on local supply chains that are vulnerable to climate change. Disruptions of existing food and water sources would have devastating consequences for sustainability and livelihoods, adding to the threats already posed by climate change in eradicating poverty. Due to their limited ability to respond to such changes, African farmers have survived and coped in a variety of forms over time. It's crucial to get a better idea of how they've achieved it so that incentives can be designed to encourage private adaptation (Schlenker *et al*., 2010). Helping smallholder farmers' coping strategies by effective public policy, investment, and concerted action will greatly boost the implementation of adaptation measures that will mitigate the negative effects of expected future climate changes, with significant benefits for Africa's most disadvantaged rural populations.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter discusses the study's summary and findings. It also makes recommendations for practice and for future research.

5.1 Conclusion

This research indicates that the mean age of smallholder farmers in the district of Ruhango is 45 years. The majority's highest education level is primary, and farming was the main source of their livelihood. The results showed that majority (91.2%) of smallholder farmers' accesses to only daily weather forecasts while how used it in their agricultural activities were only 11.9% whereas the radio was reported as the first CIS communication channel through which the majority (79.9%) received the climate information followed by Mobile phone used by 6.3%. Only family size of smallholder farmers has been statistically significant to influence the climate information access, others were not. Among the smallholder farmers and agricultural extension officers that accessed climate information most of them acknowledge that the information received was not accompanied by agronomic advices.

Lack of trust founded on the unreliability of previous climate information services provided has been identified as the key factor in the decision-making process of farmers aren't using climate information in their farm management. The participatory and coproduction between actors and through improving local collaboration, trust, capacity building of farmers will increase the uptake of climate information services. Almost all smallholder farmers agreed that the climate has changed, where more unpredictable rainfall, periodic dry spells, and the invention of new crop diseases and pests were reported by different climate disruptions. Erosion control activities have been reported as the main adaptation measure applied by smallholder farmers in the district of Ruhango to mitigate climate change disruptions.

In order to improve the resilience of small-scale farmers through use of CIS, providers of climate information can ensure timely and reliable transmission of climate information to the right users.

And smallholder farmers need to be active throughout the whole climate information development cycle, which will improve farmers' trust and access to and use of CIS to make the decisions on their farm management.

5.2 Recommendations

The smallholder farmers of Ruhango district reported radio as main source of climate information and services whereas the mobile phone was reported second accessed communication channel. Limited number of smallholder farmers used CIS in farm decision making. Lack of trust and inconsistency in previously year's climate products have been identified as key factors in not using them in farming decision-making and climate change disruptions management. As below, the main recommendations are:

(i) As primary communication platform accessed by the majority of smallholder farmers, Meteo Rwanda and other CIS provider agencies might strengthen the appropriate and timely information services to farmers disseminated via radio.

(ii) The household size, however, contributes significantly to the access to CIS communication channels throughout the district of Ruhango. The study however proposed that policymakers should encourage access to and the use of climate information services by all farming communities without considering any distinction between their socio-economic characteristics.

(iii) The priority of CIS providers should indeed be the provision of accurate, relevant and useful and timely climate information services. Furthermore, the active participation of smallholder farmers in the development of climate information systems could boost their morale in the obtained CIS and allow use of that info in their agricultural decision-making

(iv) The results indicated that only erosion control practices were adopted as an adaptation measure by the most of smallholder farmers in the study area. Therefore, boosting other scientific or community-based adaptation solutions to hold people on the road to food security is vital not only in the district of Ruhango, but nationally.

5.3 Suggestion for further research

Further research on local knowledge in climate information supply chains is needed to enhance the credibility and use of climate information services throughout Rwanda's smallholder farmers.

REFERENCES

Adele, A., & Todd, A. C. (2011). *Impacts of climate change on smallholder farmers in Africa and their adaptation strategies: What are the roles for research?International Symposium and Consultation (29-31 March, 2010, Arusha, Tanzania)*.

AGRA. (2014). *Climate change and smallholder agriculture in Sub-saharan Africa*.

Amadi, S. O., & Chigbu, T. O. (2014). The need for accurate and timely weather and climate services in a developing economy: Nigeria in perspective. *Journal of Current Research in Science*, *2*(6), 680–686.

Amegnaglo, C. J., Anaman, K. A., Mensah-Bonsu, A., Onumah, E. E., & Amoussouga Gero, F. (2017). Contingent valuation study of the benefits of seasonal climate forecasts for maize farmers in the Republic of Benin, West Africa. *Climate Services*, *6*, 1–11. https://doi.org/10.1016/j.cliser.2017.06.007

Amwata , Omondi, K. (2018). Uptake and Use of Climate Information Services To Enhance Agriculture and Food Production Among Smallholder Farmers in Eastern and Southern Africa Region. *International Journal of Advanced Research*, *6*(5), 859–873. https://doi.org/10.21474/ijar01/7106

ASSAR. (2015a). *Communicating Climate Information*.

ASSAR. (2015b). *Use and Communication of Climate Information to Support Uptake of Adaptation Action in the Semi-Arid Regions of Africa and Asia*.

Baffour-Ata, F., Antwi-Agyei, P., Nkiaka, E., Dougill, A. J., Anning, A. K., & Kwakye, S. O. (2022). Climate Information Services Available to Farming Households in Northern Region, Ghana. *Weather, Climate, and Society*, *14*(2), 467–480. https://doi.org/10.1175/WCAS-D-21-0075.1

Below, T., Artner, A., Sieber, R., & Stefan, S. (2010). Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers. *Food Policy*, *February*, 1–28.

Bharwani, S., & Barrott, J. (2016). *SDC Observatory Brief: Bringing climate services to policy makers and affected people*. http://www.gfcs-climate.org/2http://www.cs4rd.org/3http://www.climate-services.org/4http://www.jpi-climate.eu/ERA4CS

Bouroncle, C., Müller, A., Giraldo, D., Rios, D., Imbach, P., Girón, E., Portillo, F., Boni, A., van

Etten, J., & Ramirez-Villegas, J. (2019). A systematic approach to assess climate information products applied to agriculture and food security in Guatemala and Colombia. *Climate Services*, *16*(December), 100137. https://doi.org/10.1016/j.cliser.2019.100137

Bryan, E., & Behrman, J. (2013). *Community-Based Adaptation to Climate Change: A Theoretical framework, Overview of Key Issues and Discussion of Gender Differentiated Priorities and Participation* (Issue 109). https://doi.org/http://dx.doi.org/10.2499/CAPRiWP109

Buontempo, C., Hewitt, C. D., Doblas-Reyes, F. J., & Dessai, S. (2014). Climate service development, delivery and use in Europe at monthly to inter-annual timescales. *Climate Risk Management*, *6*, 1–5. https://doi.org/10.1016/j.crm.2014.10.002

Byishimo, P. (2018). ASSESSMENT OF CLIMATE CHANGE IMPACTS ON CROP YIELDS AND FARMERS' ADAPTATION MEASURES: a case of Rwanda Patrick. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9). https://doi.org/10.1017/CBO9781107415324.004

Catherine Mungai, L. S. and M. R. (2018). *Rwanda Climate Services for Agriculture*.

Churi, A. J., Mlozi, M. R. S., Tumbo, S. D., & Casmir, R. (2012). Understanding Farmers Information Communication Strategies for Managing Climate Risks in Rural Semi-Arid Areas, Tanzania. *International Journal of Information and Communication Technology Research*, *2*(11), 838–845.

Corner, A., Shaw, C., & Clarke, J. (2018). Principles for effective communication and public engagement on climate change A Handbook for IPCC authors. *Oxford: Climate Outreach*, 1–28. www.explorecommunications.ca

Coulibaly, J Y, Birachi, E. A., Kagabo, D. M., & Mutua, M. (2017). Climate services for agriculture in Rwanda: baseline survey report. In *CCAFS Working Paper* (Issue No.202, p. 69 pp.). CGIAR Research Program on Climate Change, Agriculture and Food Security.

Coulibaly, Jeanne Y, Birachi, E. A., Kagabo, D. M., & Mutua, M. (2017). *Climate services for agriculture in Rwanda What farmers know about climate information services in Rwanda* (Issue June).

Diouf, N. S., Ouedraogo, I., Zougmoré, R. B., Ouedraogo, M., Partey, S. T., & Gumucio, T. (2019). Factors influencing gendered access to climate information services for farming in Senegal. *Gender, Technology and Development*, *23*(2), 93–110.

https://doi.org/10.1080/09718524.2019.1649790

Enete, A., & Amusa, T. (2010). Challenges of Agricultural Adaptation to Climate Change in Nigeria: a synthesis from the literature. *... Science Reports. The Journal of Field ...*, *4*(December), 11. http://www.mendeley.com/research/challenges-agricultural-adaptation-climate-change-nigeria-synthesis-literature/

Epstein, J. L., Sanders, M. G., Sheldon, S. B., Simon, B. S., Salinas, K. C., Jansorn, N. R., Van Voorhis, F. L., Martin, C. S., Thomas, B. G., & Greenfeld, M. D. (2018). *School, family, and community partnerships: Your handbook for action*. Corwin Press.

FAO. (2019). *Handbook on Climate Information for Farming Communities: What farmers need and what is available*.

GFCS. (2016). *Climate Services for Supporting Climate Change Adaptation* (Issue 1170). https://library.wmo.int/pmb_ged/wmo_1170_en.pdf

Guido, Z., Knudson, C., Campbell, D., & Tomlinson, J. (2020). Climate information services for adaptation: what does it mean to know the context? *Climate and Development*, *12*(5), 395–407. https://doi.org/10.1080/17565529.2019.1630352

Hiwot Yirgu Astemir. (2014). Determinants of Food Security in Rural Households in Ethiopia. *International Instittute of Social Studies*, *June*, 70.

Huyer, S., Hansen, J., Rose, A., Vaughan, C., & Huysen, T. Van. (2017). *What We Know about Gender and Rural Climate Services Preliminary Findings and Guidance* (Issue OCTOBER).

Kalanda-Joshua, M., Ngongondo, C., Chipeta, L., & Mpembeka, F. (2011). Integrating indigenous knowledge with conventional science: Enhancing localised climate and weather forecasts in Nessa, Mulanje, Malawi. *Physics and Chemistry of the Earth*, *36*(14–15), 996–1003. https://doi.org/10.1016/j.pce.2011.08.001

Kim, J. H. (2019). Multicollinearity and misleading statistical results. *Korean Journal of Anesthesiology*, *72*(6), 558–569. https://doi.org/10.4097/kja.19087

Klein, R. J. T., Midgley, G. F., Preston, B. L., Alam, M., Berkhout, F. G. H., Dow, K., Shaw, M. R., Gitay, H., Thurlow, J., Buob, S., & Thomas, A. (2015). Adaptation opportunities, constraints, and limits. *Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects*, 899–944. https://doi.org/10.1017/CBO9781107415379.021

Kom, Z., Nethengwe, N. S., Mpandeli, N. S., & Chikoore, H. (2020). Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal*, *7*. https://doi.org/10.1007/s10708-020-10272-7

Komba, C., & Muchapondwa, E. (2012). Adaptation to Climate Change by Smallholder Farmers in Tanzania. *Agricultural Adaptation to Climate Change in Africa: Food Security in a Changing Environment*.

Kumar, K. (1989). *CONDUCTING KEY INFORMANT INTERVIEWS IN DEVELOPING CONTRIES* (Vol. 58, Issue 58).

Leung, L., & Vail, L. (2016). *Potential Impacts of Accelerated Climate Change Annual Report of Work for NRC Agreement* (Issue May).

Lohr, S. L. (1999). *Design and Analysis*. Duxbury Press.

Lynn, P. (2021). *Reducing non-sampling errors to improve the measurement of poverty and social exclusion in Europe 1 Introduction 2 Population Coverage 3 Survey Nonresponse*. *84*(July), 18–23.

Mburia, R. (2015). *Africa Climate Change Policy: An adaptation and development challenge in a dangerous world*.

Mburu, P. (2013). *Factors Influencing Access To Agricultural Information By Smallholder Farmers Through Ict Channels in Deiya Location Kiambu County*.

McGahey, D. J., & Lumosi, C. K. (2018). Climate change communication for adaptation: Mapping communication pathways in semi-arid regions to identify research priorities. *Journal of Sustainable Development in Africa*, *20*(1).

Mittal, S., & Mehar, M. (2016). Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. *Journal of Agricultural Education and Extension*, *22*(2), 199–212. https://doi.org/10.1080/1389224X.2014.997255

Muema, E. M. (2018). *Determinants Of Access And Use Of Climate Information Services Among Smallholder Farmers In Makueni County, Kenya* (Issue November).

Muhire, I., Ahmed, F., & Elbasit, M. A. M. A. (2015). Spatio-temporal variations of rainfall erosivity in Rwanda. *Journal of Soil Science and Environmental Management*, *6*(4), 72–83. https://doi.org/10.5897/JSSEM14

Mwalusepo, S., & S Massawe, stomih. (2015). Smallholder Farmers' Perspectives on Climatic Variability and Adaptation Strategies in East Africa: The Case of Mount Kilimanjaro in

Tanzania, Taita and Machakos Hills in Kenya. *Journal of Earth Science & Climatic Change*. https://doi.org/10.4172/2157-7617.1000313

Naab, F. Z., Abubakari, Z., & Ahmed, A. (2019). The role of climate services in agricultural productivity in Ghana: The perspectives of farmers and institutions. *Climate Services*, *13*(April 2018), 24–32. https://doi.org/10.1016/j.cliser.2019.01.007

Ncoyini, Z., Savage, M. J., & Strydom, S. (2022). Limited access and use of climate information by small-scale sugarcane farmers in South Africa: A case study. *Climate Services*, *26*(March 2021), 100285. https://doi.org/10.1016/j.cliser.2022.100285

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

Okumu, O. F. (2013). Small- Scale Farmers ' Perceptions and Adaptation Measures To Climate Change in Kitui County , Kenya. *Thesis*, *November*.

Ongoma, V., & Shilenje, Z. W. (2016). The effectiveness of agrometeorological information in the realization of Kenya's vision 2030; Lessons learnt from China. *Italian Journal of Agrometeorology*, *21*(1), 67–72.

Passi, V., Dubois, E., Lecestre, A., Linde, A. S., Bois, B. Du, & Raskin, J.-P. (2013). Analysis of Institutional Factors Influencing Adoption of Zero-grazing Dairy Farming Technology a mong Smallholder Farmers in Bondo SubCounty, Kenya. *Microelectronic Engineering*, *1*, 57–65. http://www.sciencedirect.com/science/article/pii/S0167931712004984

Petronila, A. (2015). *Assessing communication channels and the impact of agricultural information used by farmers in watermelon production in Yimbo East ward, Siaya County* (Issue November).

Province, S., & District, R. (2018). *REPUBLIC OF RWANDA RUHANGO DISTRICT* (Issue July 2013).

Qualtrics. (2021). *How to minimize sampling and non-sampling error*.

Rahman, H. M. T., & Hickey, G. M. (2019). What does autonomous adaptation to climate change have to teach public policy and planning about avoiding the risks of maladaptation in Bangladesh? *Frontiers in Environmental Science*, *7*(JAN). https://doi.org/10.3389/fenvs.2019.00002

Ranney, M. L., Meisel, Z. F., Choo, E. K., Garro, A. C., Sasson, C., & Morrow Guthrie, K.

(2015). Interview-based Qualitative Research in Emergency Care Part II: Data Collection, Analysis and Results Reporting. *Academic Emergency Medicine*, *22*(9), 1103–1112. https://doi.org/10.1111/acem.12735

Rarieya, M., & Fortun, K. (2015). *Food security and seasonal climate information : Kenyan challenges*. *2010*, 99–114. https://doi.org/10.1007/s11625-009-0099-8

Reay, D., Sabine, C., Smith, P., & Hymus, G. (2007). Intergovernmental Panel on Climate Change. Fourth Assessment Report. Geneva, Switzerland: Inter-gov- ernmental Panel on Climate Change. Cambridge; UK: Cambridge University Press; 2007. Available from: www. ipcc.ch. In *Intergovernmental Panel on Climate Change.* https://doi.org/10.1038/446727a

Res, C., & Lu, X. (2011). *Provision of climate information for adaptation to climate change*. *47*, 83–94. https://doi.org/10.3354/cr00950

Sandner, T. (2012). Women Farmers Adapting to Climate Change. *Diakonisches Werk Der EKD e.V. for "Brot Für Die Welt" and Diakonie Katastrophenhilfe*.

Schlenker, W., Lobell, B. D., Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., Herrero, M., Nhemachena, C., Rashid, H., Narayanan, K., Sahu, S. K., Mertz, O., Mbow, C., Reenberg, A., Diouf, A., Below, T., Artner, A., Siebert, R., … Program, S. (2010). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. *Environmental Management*, *114*(1), 83–104. http://10.0.72.88/cs/v110/i7/1240-1250%5Cnhttp://ezproxy.unal.edu.co/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=114335616&lang=es&site=eds-live%0Ahttp://stacks.iop.org/1748-9326/5/i=1/a=014010

Sebaziga, J. N. (2014). *Association between madden-julian oscillations and wet and dry spells over rwanda*. http://erepository.uonbi.ac.ke/xmlui/bitstream/handle/11295/74219/Sebaziga_Association between Madden-julian oscillations and wet and dry spells over Rwanda.pdf?sequence=1

Shalabh, I. K. (2021). Sources of non-sampling errors. In *Sampling Theory* (pp. 1–7).

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M., & Kituyi, E. (2018). The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. *Climate and Development*, *10*(5), 389–405. https://doi.org/10.1080/17565529.2017.1318744

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M., Kituyi, E., Singh, C., Daron, J., Bazaz, A., Ziervogel, G., & Spear, D. (2017). The utility of weather and climate information for adaptation decision-making : current uses and future prospects in Africa and India. *Climate and Development*, *0*(0), 1–17. https://doi.org/10.1080/17565529.2017.1318744

Stone, R. C., & Meinke, H. (2006). Weather, climate, and farmers: An overview. *Meteorological Applications*, *13*(S1), 7–20. https://doi.org/10.1017/S1350482706002519

Surabhi, M. (2013). Delivering agro-advisories through mobile phones-reality check? *Aesa*, *September*, 1–7.

Tumbo, S. D., Mwalukasa, N., Fue, K. G., Mlozi, M. R. S., Haug, R., & Sanga, C. A. (2018). Exploring information seeking behavior of farmers' in information related to climate change adaptation through ICT (CHAI). *International Review of Research in Open and Distance Learning*, *19*(3), 299–319. https://doi.org/10.19173/irrodl.v19i3.3229

UNECA. (2011). *Climate Science , Information , and Services in Africa : Status , Gaps and Policy Implications*.

UNECA. (2016). *Mainstreaming / Integrating Climate Information and Services into Legislation , Development Policies , Plans and Practices : Training Resources for Capacity Building for Legislators , Policy Makers and Civil society*.

Uwiragiye, G. R. A., Mugabowindekwe, J. T. M., Mutabazi, A., Hategekimana1, S., & Mugisha, J. (2019). Assessing the Impact of Climate Change and Variability on Wetland Maize Production and the Implication on Food Security in the Highlands and Central Plateaus of Rwanda. *Ghana Journal of Geography*, *11*(December), 1–26.

Warner, K., Van, P., Brouwer, M., van Bodegom, A. J., Satijn, B., Buit, G. L., Galema, F. M., & Buit, G. L. (2015). Climate change profile: Rwanda. In *Netherlands Ministry of Foreign Affairs* (Issue July).

Watkiss, P., Ventura, A., & Poulain, F. (2019). Decision-making and economics of adaptation to climate change in the fisheries and aquaculture sector. In *FAO Fisheries and Aquaculture Technical Paper No. 650*.

APPENDIX

Appendix 1: Printable Questionnaire Used through SurveyCTO computer application

Field	Question	Answer
Intro note	Hello, My name is NZEYIMANA Alexis I'm a student at University of Nairobi doing research in Climate Change and Adaptation for my masters' degree thesis. The study is for academic purposes and the main objective is to enhancing the smallholder farmers ‘climate resilience through access and use climate information services in Ruhango District. The information that you provide would be useful in understanding how to improve access and use of climate information services in farm decision-making and it will then be treated with utmost confidentiality. Your assistance in answering the questions truthfully and accurately will be highly appreciated. The Survey will take approximately 10-15 minutes. *Muraho,Nitwa NZEYIMANA Alexis Ndi umunyeshuri nkaba ndimo gukora ubushakashatsi bwo gusoza amashuri y'icyiciro cya kaminuza cyisumbuye. Ndagirango nkubaze ibibazo bike ku mikoreshereze ku mihindagurikire y'ikirere.Ubu bushakashatsi bugamije kongerera abahinzi ubwirinzi ku mihindagurikire y'ikirere binyuze mu kubona no gukoresha amakuru y'ikirere*	

Field	Question	Answer
	mu karere ka Ruhango.Amakuru muduha ni ingirakamaro mu kumva uburyo hanozwa imitangire n'imikoresherezwe ya serivisi z'ubumenyi bw'ikirere mu buhinzi kandi turabizezako imyirondoro yanyu ari ibanga kandi azakoreshwa gusa muri ubu bushakashatsi.Ubufasha bwanyu mu kudusubiza ibi bibazo turabwishimira.Iki kiganiro kirafata iminota icumi kugeza kuri cumi nitanu.	
consent *(required)*	Would you like to continue? *Ese wemeye ko tuganira?*	1 Yes /Yego 0 No /Oya
Survey		
Survey > Section 1: Farmer identification		
district *(required)*	District *Akarere*	district_code district_name
sector *(required)*	Sector *Umurenge*	sector_code sector_name
cell *(required)*	Cell *Akagari*	cell_code cell_name
village *(required)*	Village *Umudugudu*	village_code village
gender *(required)*	Gender *Igitsina*	1 Male /Gabo 2 Female /Gore
age *(required)*	How old are you? *Ufite Imyaka ingahe?*	
religion *(required)*	Religion *Imyemerere*	1 Christian /Umukirisitu 2 Muslim /Umusilamu 3 Traditional /Gakondo 4 No religion /Nta dini

Field	Question	Answer
marital_status *(required)*	Marital status *Irangamimerere*	1 Single /Ingaragu 2 Married /Arubatse 3 a widow /Umupfakazi 4 Temporary separated /Batandukanye by'agateganyo 5 Divorced /Batandukanye
people *(required)*	How many people are in your household? *Ni abantu bangahe baba mu muryango wanyu?*	
category *(required)*	Ubudehe category: *Ikiciro cy'ubudehe:*	1 1st Category /Icyiciro 1 2 2nd Category /Icyiciro 2 3 3rd /Icyiciro 3 4 4th /Icyiciro 4
level *(required)*	What is your education level? *Wize amashuri angahe?*	1 P1/Umwaka wa 1 w'amashuri abanza 2 P2 /Umwaka wa 2 w'amashuri abanza 3 P3/Umwaka wa 3 w'amashuri abanza 4 P4/Umwaka wa 4 w'amashuri abanza 5 P5/Umwaka wa 5 w'amashuri abanza 6 P6/Umwaka wa 6 w'amashuri abanza 7 S1/Umwaka wa 1 w'amashuri yisumbuye 8 S2/Umwaka wa 2 w'amashuri yisumbuye

Field	Question	Answer
		9 S3/Umwaka wa 3 w'amashuri yisumbuye 10 S4/Umwaka wa 4 w'amashuri yisumbuye 11 S5/Umwaka wa 5 w'amashuri yisumbuye 12 S6/Umwaka wa 6 w'amashuri yisumbuye 13 TVT/Imyuga 14 A3 15 A1 16 A0 17 Masters 18 PhD 19 illiterated /Nta mashuri yize
secondary_income *(required)*	What is your secondary source of income other than crop farming? *Ni ubuhe buryo bundi bukwinjiriza amafaranga?*	
Survey > Cultivated land		
size *(required)*	What is the total size of your land? *Ahantu muhinga hangana gute?*	1 Good enough/Burahagije 2 Enough/Buri mu rugero 3 Small/Buto 4 Very small/Buto cyane
soil *(required)*	What is the location of your farm? *Ese muhinga ahagana he?*	1 In the valley/ Mu gishanga 2 At hill/Imusozi 3 In between/Inkuka 4 In both /Mu gishanga n'Imusozi

Field	Question	Answer	
ownership *(required)*	Under what land ownership is your land? *Ese ubutaka muhinga ni ubwande ?*	1	Government/ Ubwa leta
		2	Rent /Ubwatishanyo
		3	Borrowed /Ubutirano
		4	Rent by Cooperative / Ubwa koperative
		5	extended family land/Ubutaka bw'umuryango
		6	My land /Ubutaka bwanjye bunyanditseho
experience *(required)*	How long have you been in crop farming? *Ese mumaze imyaka ingahe mu buhinzi*		
crop *(required)*	What is the dominate crop? *Ni ibihe bihingwa mukunda guhinga?*	1	Cassava /Imyumbati
		2	Maize Ibigori
		3	Soy /soya
		4	Beans /Ibishyimbo
		5	pineapple/Inanasi
		6	bananas/Urutoki
		7	coffee/Ikawa
		8	sweet potatoes/ Ibijumba
		9	others/Ibindi
class *(required)*	Why do you practice agriculture? *Ni iki kibatera gukora ubuhinzi?*	1	To satisfy the family /Guhinga ibihagije umuryango wanjye
		2	For market/Guhingira isoko
		3	For both family and Market /Guhinga ibihagije umuryango

Field	Question	Answer
		wanjye ndetse no guhinigira isoko
practice *(required)*	What type of agriculture do you practice? *Ese mukora mute ubuhinzi bwanyu ?*	1 Modern /Bya kijyambere 2 Tradition/Bya gakondo 3 Mixed /Kijyambere na gakondo icyarimwe
member *(required)*	Are you a member of any agricultural cooperative? *Ese hari cooperative y'ubuhinzi mubarizwamo?*	1 Yes/Yego 0 No /Oya
activity *(required)*	Do you have any leadership position in your cooperative? *Ese haba hari inshingano mufite mu buyobozi bwa koperative?*	
Survey > Section 2: Opinion towards climate information channels		
awareness *(required)*	Are you aware any of weather/climate information services issued by the Rwanda Meteorology Agency? *Ese uzi serivisi z'amakuru atangwa kubyerekeranye n'iteganyagihe atangwa na metewo Rwanda*	1 Yes /Yego 0 No /Oya
decide_yes *(required)*	If yes, what kind of services are you aware of?	

Field	Question	Answer
	Niba ari yego, ni izihe serivisi muzi?	
decide_no *(required)*	If no, "there is no information? *Niba ari oya, "nta makuru mfite"*	
event *(required)*	Do you get warnings about extreme events? *Ese mujya mubona integuza ku bihe bidasanzwe ?*	1 Yes /Yego 0 No /Oya
warning *(required)*	What are those warning? *Nizihe nteguza mukunze kubona ?*	1 Drought /Amapfa 2 heavy rain /Imvura nyinshi 3 Floods /Imyuzure 4 Pests /Udukoko twangiza imyaka 5 plant diseases /Indwara z'ibihingwa 6 Other events /Ibindi
event_no *(required)*	If no,"There is no information? *Niba ari oya,"nta makuru mfite" ?*	
information *(required)*	How often do you receive weather/climate services? *Ni kangahe mubona amakuru ku byerekeranye n'ubumenyi bw'ikirere ?*	1 daily /Buri munsi 2 Weekly /Buri cyumweru 3 Monthly /Buri kwezi 4 Seasonally /Buri gihembwe cy'ihinga

Field	Question	Answer
		5 several times a year /Inshuro nyinshi mu mwaka 6 once a year /Inshuro imwe mu mwaka 7 I don't receive any information /Ntabyo mbona
channel *(required)*	What is your priority channel of climate information services that you received? *Nuwuhe muyoboro mukunda kuboneramo amakuru ajyanye n'ikirere ?*	1 Farmer promoters /Abafashamyumvire mu buhinzi 2 Radio /Radiyo 3 Television /Televiziyo 4 Internet /Murandasi 5 Telephone /Telefoni 6 Face-to-Face /Imbonankubone 7 Training /Amahugurwa 8 Farmer-to-Farmer /Umuhinzi ku muhinzi 9 Other /Ibindi
Survey > Section 3: General attitudes towards adaptation to climate change		
use_all *(required)*	In the last 2 years, did you receive any climate information? *Mu myaka ibiri ishize mwigeze mubona amakuru ajyanye n'iteganyagihe ?*	1 Yes /Yego 0 No /Oya
info_yes *(required)*	If yes, did you use the climate information service you received?	

Field	Question	Answer
	Niba ari yego,mwaba mwarayakoresheje mu buhinzi bwanyu ?	
info_no *(required)*	If no, why didn't you use it? *Niba ari oya,ese ni kuki mwaba mutayakoresha ?*	
accuracy *(required)*	Is the meteorological information you received reliable? *Ese amakuru mwabonye ya metewo arizewe ?*	1 very reliable /Arizewe cyane 2 Reliable /Arizewe 3 moderate reliable /Yizewe mu rugero 4 less reliable /Ntiyizewe 5 it is not reliable /Ntiyizewe na gato
help *(required)*	Do you believe that climate information services can help you in agricultural decision making? *Ese mwemerako amakuru kw'iteganyagihe haricyo yabafasha mu buhinzi bwanyu*	1 Yes /Yego 0 No /Oya
change_yes *(required)*	If yes, how can it help? *Niba ari yego ,mwumva yabafasha ate ?*	
change_no *(required)*	If no, why do you think so?	

Field	Question	Answer	
	Niba ari oya,kuki mubyumva mutyo ?		
trust *(required)*	In relation to climate information services, which one do you trust the most? *Mu byerekeranyen'iteganya gihe ry'ikirere,ni iki mwaba mwizera cyane*	1	religious beliefs /Imyemerere y'idini ryanjye
		2	CIS provider/ Metewo Rwanda
		3	old people /Abantu bakuru
		4	traditional knowledge /Ubumenyi gakondo
		5	Nothing /Ntanakimwe
Survey > Section 4: Practices towards adaptation to climate change			
beliefs *(required)*	Do you think the climate is changing? *Ese wemera ko ibihe by'ikirere byahindutse ?*	1	Yes /Yego
		0	No /Oya
example_yes *(required)*	What have you already experienced as effects of climate change in your area? *Ni izihe ngaruka ziturutse ku mihindukire y'ikirere mukunda guhura nazo ?*	1	heavy rain /Imvura nyinshi
		2	extreme heat /Ubushyuhe bukabije
		3	Drought /Amapfa
		4	Erratic rainfall patterns /Imvura igwa nabi
		5	Floods /Imyuzure
		6	Landslides /Inkangu
		7	plant diseases /Indwara z'ibihingwa
		8	seasonal fluctuations /Ihindagurika ry'ibihe by'ihinga

Field	Question	Answer
		9 Nothing /Nta nakimwe 10 Other /Ibindi
expert_no *(required)*	How do you understand this? *Niba ari oya,mubyumva mute ?*	
what_effects *(required)*	What effects did it have on you personally? *Ni izihe ngaruka byaba byarabagizeho ku giti cyanyu ?*	
climate_note	When we say "adapt to climate change" we mean those actions that we take in our lives to deal with climate change and its impacts *Iyo tuvuze "guhangana n'imihindagurikire y'ikirere n'ingaruka zabyo",tuba tuvuze ibikorwa mu buzima bwacu duhindura kugirango tubashe guhangana n'ingaruka*	

Field	Question	Answer
	z'imihindagurikire y'ikirere	
actions *(required)*	Among the following actions, have you taken any of them to adapt to climate change and to reduce its impacts? *Muri izi ngamba cg se ibikorwa bikurikira haribyo mwakoze kugirango muhangane n'ingaruka z'imihindagurikire y'ikirere*	1 crops that tolerate heavy rains /Gutera ibihingwa byihanganira imvura nyinshi
		2 Crops that tolerate low rainfall /Gutera ibihingwa byihanganira imvura nke
		3 Watering or Irrigation /Kuvomerera
		4 Spraying the pesticides /Gutera umu ti wica udukoko
		5 change field location /Guhindura aho mwahingaga
		6 Erosion control /Imirwanyasuri
		7 agro-forestry / Gutera ibiti bivangwa n'imyaka
		8 Temporary suspension of cultivation /Guhindura umwuga
		9 I don't do anything /Nta nakimwe
constraints *(required)*	What are the constraints do you meet in adapting to climate change? *Ese ni izihe mbogamizi muhura nazo zituma mudahangana n'imihindagurikire y'ikirere*	1 limited capacity /Ubushobozi buke
		2 little knowledge /Ubumenyi buke
		3 insufficient and unreliable information /Amakuru adahagije kandi atizewe

Field	Question	Answer
		4 Negligence /Kutabyitaho 5 I don't know /Ntabyo nzi
What_suggestion *(required)*	What are your suggestions on changes or improvements do you want to see in climate services delivery and communication? *Ese nibiki wumva wifuza ko byahinduka cyangwa se byakongerwa mu mitangire n'imisakarize ya serivisi z'ikirere*	