# Investigating weather information needs of smallholder farmers in the Eastern Cape province of South Africa

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# PLAGIARISM DECLARATION

I declare that this is my own work. Information derived from published and unpublished work of others has been acknowledged and referenced.

Abenathi Mantshiyose

| Signed by candidate | Date: 21 July 2022 |
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# Abstract

South Africa is continuously experiencing irregular weather and climate, which is attributed to climate change and the El Niño Southern Oscillation. These have resulted in temperature increases, irregular rainfall patterns, and increased frequency of extreme events. In South Africa, smallholder farmers are the most vulnerable to extreme weather events due to their limited capacity to adapt. Their vulnerability results from a series of factors constraining their ability to adapt, such as limited resources, knowledge, and skills. Furthermore, smallholder farmers are highly dependent on rainfed agriculture, making them more sensitive. The lack of weather information that is tailored for user needs or adapted well enough is also a concerning issue that exacerbates the living conditions of smallholder farmers. This makes it difficult for them to sustain their agricultural activities.

Over the years, weather information has been recognized as having the potential to be useful in agriculture, especially in informing farming practices, planning, and reducing weather events impacts among smallholder farmers. However, access and use of weather information that applies to the context of smallholder farmers which is tailored to meet smallholder farmers needs, has been limited and has contributed to limited understanding and low use levels of weather information. This has increased the need to understand the weather information needs of smallholder farmers as this is important to ensure that farmers can effectively use and understand the information. In South Africa, limited studies have looked at the weather information needs of smallholder farmers. Hence, a shift of attention towards investigating the weather information needs of smallholder farmers has increasingly become necessary.

The present study investigated how to better communicate the weather information needs of smallholder farmers in the Eastern Cape province of South Africa. A mixed-methods approach was used to collect and analyze the data. Interviews with open-ended and closed-ended questions were conducted with smallholder farmers and agricultural extension officers. Interviews were conducted to gain an insight on the baseline and characteristics of weather information farmers receive and their needs. The same was done with extension officers to get their insight on the needs of farmers and the needs of extension officers.

The findings of the study confirm that the current weather information system is inefficient as the information does not fully meet the needs of smallholder farmers. Most of the farmers expressed that they currently receive information on rainfall, temperature, and heavy rainfall but stated that they would like to receive information on drought as they are currently experiencing dry periods. The farmers mentioned that they receive weather information mostly from the television, radio, and a few from weather apps. Most of the farmers receive weather information in maps and audio, expressing that maps make it easy for them to visualize and understand the information. From the television, they receive the information in IsiXhosa and IsiZulu, and they mentioned that weather information in IsiXhosa is easy to understand as it is their local language. In weather apps, farmers mentioned that they receive weather information in English and expressed concerns about understanding weather information in English. As a result, most farmers preferred receiving weather information in IsiXhosa as they can understand the language. Additionally, farmers also expressed that they only receive weather information daily, and they stated that they would like to receive weather information daily, weekly, monthly, and seasonally to plan their farming activities and to know when to plant. Furthermore, most of the farmers expressed that they encounter some challenges with the information they receive. Some of the challenges included issues such as the inaccuracy of the information and scale issues. The farmers complained that the information they receive is not downscaled to their local scale, making it difficult for them to apply the information on their local scale decisions. Therefore, without significant improvement of the issues mentioned above and addressing the weather information needs of farmers, weather information use and understanding will remain low and will increase the vulnerability of smallholder farmers to extreme weather events. To prevent this, there is a growing need for weather information to meet the needs of smallholder farmers so that they can understand and use the information efficiently, especially in the face of increasing extreme weather events such as drought in South Africa.

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# List of acronyms and abbreviations

| | |
|---|---|
| ENSO | El Niño Southern Oscillation |
| GDP | Gross Domestic Product |
| ha | Hectare |
| MAC | Mean Annual Loss |
| SABC | South African Broadcasting Corporations |
| SAWS | South African Weather Service |
| SSA | Sub-Saharan Africa |
| WCS | Weather and Climate Services |

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# Chapter 1: Introduction

This chapter provides the background information and rationale of this study. It includes information on the importance of smallholder farming in South Africa, challenges faced by smallholder farmers, and the importance of weather information on smallholder farmers. The chapter also highlights the importance of further research to investigate the weather information needs of smallholder farmers in South Africa to communicate the information better and effectively increase its use. Lastly, this chapter outlines the aim and objectives of the study.

## 1.1 Importance of smallholder farming in South Africa

Globally about 82% of activities related to crop production are rainfed, and crop yields are under threat to climate change, extreme weather and climate events, especially in developing regions (Mongi *et al.,* 2010). In Africa, agriculture is a source of livelihood, food security, and income (Asenso-Okyere & Mekonnen, 2012). For example, in Sub-Saharan Africa (SSA), agriculture contributes about 23% of the Gross Domestic Product (GDP) (Goedde *et al.,* 2019). In South Africa, agriculture plays an important role in creating and supporting livelihoods, reducing poverty, providing food, employment, and income. According to DAFF (2017), the agricultural sector accounts for 2.5% of the South African GDP and provides employment to 4.5% of the population. Moreover, agriculture produces about 2.6 million tons of food in the African continent. Despite this, rural areas in Africa have the highest poverty and food insecurity levels. About 220 million people in SSA do not have enough food to eat, and three-quarters of the population live in rural areas (Hudson *et al.,*2017).

In developing regions most of the population is made up of smallholder farmers. For example, in Southern Africa, about 70% of the population is smallholder farmers (Nhamo *et al.,* 2019). In South Africa, about 2% of households practice smallholder farming, and 18% practice subsistence agriculture (DAFF, 2017). The smallholder farming sector in South Africa is undertaken on 13% of the agricultural land, it consists of 4 million black farmers in the former homeland areas, which are marginalized areas with poor soils (Aliber & Hart, 2009). In South Africa, the Eastern Cape province has the second largest number of smallholder farmers and is ranked among the provinces with the highest poverty levels (Mujuru & Obi, 2020). About 70.6% of the population in the province is poor (Stats Sa, 2017). Smallholder farmers are a diverse group of farmers with different individual characteristics, and the term is often interchangeably used with “small-scale” or “resource-poor” (Fanadzo & Dube, 2018). According to Aaron (2012), smallholder farmers own small pieces of land, grow subsistence and cash crops, and are involved in rearing livestock such as sheep, cattle, pigs, and goats. Smallholder farming is undertaken in small land holdings of less than 1.6 ha (hectares) (Fanadzo & Dube, 2018), and small land sizes limit food production.

In South Africa, smallholder farming is important for household food security, but smallholder farmers are subject to extreme weather and climate conditions, which lower their productivity. The low productivity in South Africa's agriculture is also a result of social factors. According to Neves & Du Toit (2013) low productivity in South Africa's agriculture is a direct result of the historical patterns of dispossession and impoverishment where people's land was taken from them, which resulted in the erosion of historically successful productive land systems and livelihoods. Despite low productivity, smallholder farming has the potential to reduce the vulnerability of rural poor farmers and to improve farmers livelihoods (Baiphethi & Jacobs, 2009). However, the potential of smallholder farming is limited by challenges within smallholder farming communities which act as a barrier.

## 1.2 Challenges faced by smallholder farmers

In many African countries, climate change is a major threat to food insecurity. In South Africa, it threatens the country's food security, water resources, employment, and health. Smallholder agriculture is primarily rainfed and is directly dependent on weather and climate events, and is very sensitive to weather variability and climate change (Sibhatu & Qaim, 2017). In South Africa weather is variable, and it is characterized by a highly variable rainfall which presents the most risks to smallholder farmers (Roffe *et al.,* 2019). Research studies relate South Africa's rainfall variability to the El Niño Southern Oscillation (ENSO), which is also regarded as an indicator of climate variability (Rouault *et al.,* 2013; Richard *et al.,* 2001).

Despite significant contributions of the agricultural sector to people’s livelihoods, smallholder farmers suffer the most during extreme weather and climate events. Some of the challenges include that, smallholder farmers lack proper infrastructure, financial resources, fertilizers, farming equipment, and proper access to services and weather information (Maponya *et al.,* 2013). Secondly, the rural areas where smallholder farmers are located are a barrier to adaptation and accessibility of resources (Aaron, 2012). For example, farmers have to travel long distances to access resources such as farming equipment in the nearby towns, further decreasing their limited financial resources. Smallholder farmers also have a low adaptive capacity and a limited ability to detect the likelihood of an extreme event due to high illiteracy levels and limited skills (Nhamo *et al.,* 2019).

Limited access to weather information has caused farming communities to rely more on their indigenous knowledge and experiences to predict upcoming weather conditions (Rankoana, 2017). However, the complexity of climate change events and changing weather patterns are now making it difficult for farmers to rely solely on their indigenous knowledge and farming experiences (Naab *et al.,* 2019). According to Naab *et al.* (2019) uncertainty on upcoming weather conditions has grown and has affected farmers planting patterns as their farming calendars no longer match weather patterns. This uncertainty restricts farmers from adapting and taking advantage of favorable climate conditions, therefore increasing their vulnerability. As a result, it is difficult for farmers to adapt to weather and climate events as they do not have up to date information on the climate and weather (Baethgen *et al.,* 2003). Weather information could help better manage crops sensitive to changes. These challenges present a concern, as, within South Africa, the frequency of extreme events are expected (Pfahl *et al.,* 2017). In the face of expected extreme events, van der Burgt *et al.* (2018) have noted that knowledge on current and upcoming weather is crucial for successful farming practices and farm management.

## 1.3 Importance of weather information in agriculture

Rainfed agriculture is very sensitive to extreme events, and with increasing climate change, the vulnerability of smallholder farmers is projected to increase (Cooper *et al.,* 2008). According to Meza *et al.* (2008), the importance of weather information in rainfed agriculture has grown to allow farmers to allocate resources in a manner that responds to anticipated weather events. Several studies have examined the usefulness of weather information and have come to the conclusion that this information can help in informing farming activities on time to adapt to weather variability and to improve farm management in supporting farmers in deciding the best plants or crops to plant (Singh *et al.*, 2018; Vincent *et al*., 2013; Archer, 2003). Weather information has been stressed by (Fitt, 2014) to be of paramount importance for sustaining agricultural production under extreme weather events and changing climate conditions.

Weather and climate services (WCS) have become a crucial tool for the timely production and delivery of weather and climate information, allowing farmers to make informed decisions about their farming practices (Hansen *et al.,* 2019). The provision of weather information can potentially decrease the effects of extreme weather events on agriculture. This information has been noted to influence farmers planting dates, farmland preparation, and harvesting time (Muema *et al.,* 2018). Weather information is communicated through various sources. In South Africa, the most used sources to disseminate weather information, are radio, television, internet, and bulletins (Popoola *et al.,* 2020). The South African Weather Service (SAWS) is the main provider of weather information in South Africa (Johnston, 2008). Therefore, to be effectively communicated and used weather information must be tailored to meet user needs and should be disseminated in a format that is understood by the user, at an appropriate time, frequency, and in a language that is easy to understand to avoid difficulty in understanding the information and to prevent misinterpretation (Walker *et al.,* 2001). With intensifying extreme weather events such as drought and heatwaves in South Africa, water scarcity and food insecurity are increasing, and the agricultural sector is experiencing millions of rand losses every year (Jordaan, 2017). Appropriate weather information is needed to better inform farmers and to reduce losses and enhance adaptation. To achieve this, Moeletsi *et al.* (2013) indicate that this can be accomplished if weather information is tailored to meet farmers needs. In South Africa, limited studies have been conducted on the weather information needs of smallholder farmers. It is from this gap that this research emerges. Understanding the needs of smallholder farmers concerning weather information is important as it can help to better inform the design and communication of weather information to meet user needs and can further help in integrating farmers and producers in the formulation and dissemination of weather information (Gbangou *et al.,* 2020). Better design and communication of weather information can potentially improve the use of weather information and enhance farmers adaptation to extreme weather events.

## 1.4 Problem statement

Weather information is available, and it has the potential to help farmers make decisions on their farming activities. However, several studies have reported that weather information is poorly communicated in terms of its format, frequency, and language (Ncoyini *et al.,* 2022; Vaughan & Dessai, 2014; Fitt, 2014). Probabilities are used, which are difficult to understand, especially for smallholder farmers due to their low literacy level, which directly affects their use and understanding of the information (Lemos *et al.,* 2012). According to Vaughan & Dessai (2014), weather information is sometimes not communicated in the local language of farmers. For example, in the case of seasonal forecasts, English is used, which is not the farmers local language, and complex terminology is also used to communicate the information. In addition, there are issues of uncertainty with weather information, and sometimes the information is inaccurate, untrustworthy, or misleading. Inaccurate and untrustworthy information causes farmers to make less effective decisions on their farming practices. Therefore, weather information is inefficient in the way that it is communicated. Poor communication is also linked to smallholder farmers limited adoption of information. In smallholder farming communities, several factors, such as lack of skills and resources, contribute to the limited adoption of weather information (Hansen *et al.,* 2019). Therefore, users of information need to be considered in the process of communicating weather information in order for the information to be efficient. The study is interested in the better communication of weather information in terms of its format, language, source, and frequency to improve understanding and use. In support of this, Lugen *et al. (*2018) state that the production of high-quality weather information that is easy to understand and use is fundamental to the resilience of societies.

## 1.5 Research aim and objectives

The study's aim is to investigate the weather information needs of smallholder farmers towards better communication of the information in the Eastern Cape province of South Africa.

This investigation of the weather information needs of smallholder farmers can provide a better understanding of the issues farmers face regarding the information they receive, including reasons for not using the information in the decision-making process. The study seeks to achieve the following objectives:

1. To establish the baseline and characteristics of weather information that smallholder farmers receive and use.
2. To investigate the kind of weather information smallholder farmers need beyond current baseline.
3. To identify how weather information can be improved and better communicated in terms of format, language, source, and frequency.

## 1.6 Outline of thesis chapters

**Chapter 1:** The current chapter provides an overview of the current research. It provides a background of the context of the study, outlines the importance of agriculture in South Africa, challenges faced by smallholder farmers, challenges associated with weather information and importance of weather information in meeting user needs. Lastly it presents the aim and objectives of the study.

**Chapter 2:** This chapter presents an overview of the available literature which includes an explanation of weather information, an overview of the challenges associated with weather information use and understanding, and importance of weather information on users decision making.

**Chapter 3:** This chapter provides an overview of the study area by providing a description of the Eastern Cape province in terms of its climate and agricultural system. Furthermore, it provides a description of the research area in the Eastern Cape, Maclear. It includes an overview of Maclear's demographics, climate, and agriculture. The chapter also presents the data collection, sampling and analysis methods employed in the study. It also details the ethical considerations.

**Chapter 4:** This chapter presents the research findings which were collected from the interviews that were conducted with the participants that were involved in this study. It includes the farmers demographic information, the type of weather information farmers and agricultural extension officers receive including the characteristics of the information and the decisions made. This chapter also focuses on the weather information needs of farmers and extension officers. Results extracted from the responses of extension officers were looked at for comparison purposes to note if there are similarities or differences in the weather information farmers and extension officers receive and need. Furthermore, to inform the improvement of weather information.

**Chapter 5:** This chapter provides a discussion of the key findings of the study. It discusses the efficiency of the current weather information system, improvement of the current system, and lastly the specific role of agricultural extension officers.

**Chapter 6:** This chapter concludes the study, where it summarizes the key findings of the study, and outlines the importance of the study.

# Chapter 2: Literature review

Firstly, this chapter defines different information types, such as weather, climate, and seasonal forecast information. In addition, the chapter explores the known challenges associated with weather information in terms of its use and understanding. Lastly, this chapter explores the importance of weather information on farmers livelihoods and decision-making. The need for weather information is stressed that is not produced to be produced, communicated, and tailored for its user needs.

## 2.1 Weather information

Access, use, and understanding of weather information have increasingly become important in the agricultural sector and are playing a more significant role in the decision-making process, especially in the face of increasing extreme weather and climate events such as drought and floods. Extreme events are the most damaging, but they are difficult to predict, and weather information is valuable for understanding extreme events and any weather and climate (Werndl, 2016). Farmers use different types of information to inform their farming practices and cope with adverse impacts of weather and climate. These include weather information, climate information, and seasonal forecast information. According to Werndl (2016) & Singh *et al.* (2018), weather and climate are fundamentally different. The most used definition for weather and climate, according to Arguez & Vose (2011), is that weather is a state of the atmosphere at a point in time, while climate is the statistical distribution of weather over a long period for example 30 years. Weather information is the weather forecast of weather conditions of a place at a particular time, and the prediction can be for a day or a week (Fitt, 2014). The SAWS is the main service provider of weather, climate, and seasonal forecast information in South Africa (Johnston, 2008). According to Popoola *et al.* (2020) in South Africa, weather forecasts in South Africa are commonly disseminated through weather reports on television, radio, and the internet. The most frequently used languages to communicate weather information include English and local languages such as IsiXhosa and IsiZulu, especially on television and radio (Popoola *et al.,* 2020). Weather forecasts support agriculture by detecting early warning signs, which are very useful in coping with current conditions and informing farmers practices and decision-making, thereby limiting risk (Mudombi & Nhamo, 2014).

Singh *et al.* (2018) define climate information as the historical observations, short-term forecasts, and medium to long-term projections of climate conditions. To further expand on this definition, short-term climate information encompasses weather and climate forecasts with time periods of less than a year (Soares *et al.,* 2018). Unlike weather forecasts which predict the weather, seasonal forecasts predict the climate and estimate the likelihood of a forthcoming season and how conditions such as rainfall and temperature may develop (Johnston, 2008). According to Palmer (2014) seasonal forecasts are an estimation of the atmosphere from a few hours to a year. In South Africa, seasonal forecasts generally consist of an outlook of the temperature and precipitation for the rainfall season of a specific area (Johnston *et al.,* 2004). Seasonal forecasts are broadly categorized into probabilistic and deterministic forecasts (Mkuhlani, 2021). Deterministic forecasts are expressed as the best value for a specific region or location in time, while probabilistic forecasts are expressed as the probability of an occurrence of an event using pre-defined categories such as above, near, or below normal (Mason, 2012).

The importance of seasonal forecasts has been noted by researchers (Selato, 2017; Fitt, 2014). Over the years, seasonal forecasts have improved farming productivity and disease prediction (WAMIS, 2003). They have been noted to have the potential to improve farmers preparedness and resilience to seasonal weather variability through low-cost input strategies such as mulching before and after the cropping season (Johnston, 2004). Fitt (2014) mentions that seasonal forecasts are helpful in terms of knowing the appropriate time for farming, preparation of farmland, and harvesting. However, despite the great potential of seasonal forecasts in agriculture, they are not commonly used as compared to weather forecasts (Selato, 2017). For example, the uptake of seasonal forecasts among smallholder farmers is low compared to commercial farmers (Vogel, 2000). Several authors attribute the limited uptake and use of seasonal forecasts to a lack of awareness, reluctance to change farming practices, limited accessibility of predictions and resources (Soares & Dessai, 2016), and complexity in format and language used to communicate the forecasts (Vogel, 2000).

The different types of information are essential to understand, as they have a great potential to inform farmers practices and decision-making. However, for these to be useful, they need to be produced and communicated in a way that is relevant for user needs. In the case of weather information, Daron *et al.* (2015) and Ranger *et al.* (2010) state that for weather information to be relevant, scientists must provide information that is the best fit for its purpose in ways that can be integrated into users decisions. In support of this, Goddard *et al.* (2010) state that weather information relevance should be dictated by the nature of the risk being managed, the area of interest, context-specific realities, and user context. Therefore, weather information users are essential to know and understand, as these are individuals or groups of people that use weather information to inform their decisions and manage risks (Singh *et al.,*2018).

## 2.2 Challenges associated with weather information

Over the years, information producers have improved the skill and quality of observational networks and forecasts across time and geographical scales (Hou *et al.,* 2014). Singh *et al.* (2018) state that there has been a growing volume of weather information in African countries, however, despite the increasing volume of weather information, in South Africa, the usefulness of this information for users, especially smallholder farmers, remains a significant challenge. Studies in Africa and the rest of the world have found that several challenges impede farmers use of weather information; some of the challenges include credibility, salience, scale, and cognition. (Bunyan *et al.,* 2015; Ziervogel *et al.,* 2008; Lemos *et al.,* 2002). These challenges often cause weather information to be difficult to use, understand and apply in context-specific decision-making. As a result, this further denies farmers the opportunity to make well-informed decisions that enable them to select appropriate farming strategies that promote adaptation (Baethgen *et al.,* 2003).

Firstly, credibility has to do with the reliability, trustworthiness, and dependability of the information (Ziervogel, 2004; Patt & Gwata, 2002). Credibility also relies on the performance of the past information in terms of its reliability, trustworthiness, and dependability because if the information has been deemed to be correct in the past, then the users will consider it credible and vice-versa (Crane *et al*., 2010; Ziervogel, 2004; Patt & Gwata, 2002). Patt & Gwata (2002) also explain that if the source of weather information has been associated with wrong past forecasts, then the information will not be considered credible until trust is earned. Improving the trustworthiness of weather information communication requires a strong network between information producers and its users (Ingram *et al.,* 2002). A strong network can ensure that information production and provision is tailor-made for users and their needs (Soares & Dessai, 2018; Dilling & Lemos, 2011). Dilling & Lemos (2011) state that achieving a strong network requires constant interaction between the producers and users in the process of information production. Constant interaction has been noted to have the potential to unearth new ways of producing, communicating, and using weather information (Fitt, 2014).

According to Dilling & Lemos (2011) and Soares & Dessai (2016), accessibility determines weather information usability. Accessibility entails communication, language, format, and understanding (Soares & Dessai, 2016). For example, in many parts of SSA, weather information is not communicated in the local languages (Feleke, 2015). Limited communication of weather information in the local language makes it difficult for farmers with a low education level to understand the information. As a result, it is difficult for smallholder farmers to incorporate the information into their decisions. Smallholder farming communities have their own needs and capacities. Therefore, for weather information to be understood and used by smallholder farmers, it must be produced and communicated with means fitting the community of the farmers.

According to Patt & Gwata (2002) and Ziervogel (2004), salience is the perceived relevance of the information to user contexts and needs (Hansen *et al.,* 2011). Hansen *et al.* (2011) mention that a lack of relevance of weather information is caused by a lack of detail in forecasts about farmers location and related farming interventions and is linked to the issue of scale. Scale is known to play a role in constraining the effective use of weather information (Ziervogel, 2004). Scale as a constraint relates to the lack of relevance of weather information at the local scale. For example, weather information in Africa is often generalized and not downscaled, resulting in the lack of coverage of the local scale (Hansen, 2019). Limited downscaling of weather information is common in many rural parts of Africa and has been associated with the absence of weather stations, which has resulted in limited data availability at the local levels, primarily where most smallholder farmers reside (Dinku, 2019). Ziervogel (2004) has found timescale to be also a constraint to the use of weather information. For example, the onset of rainfall and dry periods are critical for farmers decision-making and need to be delivered at an appropriate timescale (Dilling & Lemos, 2011). Timescale influences the effectiveness and use of the weather information.

Lack of cognition is a challenge when users cannot understand and correctly interpret the information (Patt & Gwata, 2002). Lack of understanding of weather information sometimes arises from the format in which the information is presented (Feleke, 2015). For example, in the case of seasonal forecast information, this information is often presented in probabilities and percentages (Hansen *et al*., 2011; Young & Dugas, 2011; Lemos *et al*., 2002), which is difficult to understand, especially for smallholder farmers. Difficulty in understanding has also been attributed to the low level of education of smallholder farmers and consequent difficulties in understanding probabilities

(Ncoyini *et al.,* 2022). As a result, this makes it difficult for smallholder farmers to use the information.

Lastly, a vital but often overlooked aspect of weather information in terms of its demand and use is the capacity of producers to articulate the demands of weather information users effectively and to have the ability to produce information that is needed. Lemos *et al.* (2012) state that the usefulness of weather information depends on the level and quality of the information and how the information fits the context of users to enable effective decision-making. Soares & Dessai (2016) contend that top-down production of weather information does not translate to its usability. As a result, producers have concerns that information is not used to its full potential by its users despite the potential benefits of the information (Marshall *et al.,*2011). In South Africa, this is indicated to be also caused by the inability of producers to understand the demands of information users, which then causes a demand and supply gap, where information produced does not satisfy user demands (Hansen *et al.,* 2019). For example, smallholder farmers are often not engaged with or given a voice to express the kind of information they need (Lemos *et al.,* 2012). Producers and users of information have different capacities and needs and therefore need to engage directly to produce usable and useful information to reduce this usability gap. The usability gap stems from what producers of weather information think is useful compared to what is helpful for smallholder farmers in their decision-making process (Lemos *et al.,* 2012). Moreover, sometimes producers cannot produce information despite its need because the information needed sometimes makes no sense to produce because of a lack of confidence or meaning. As a result, this cause a misalignment between the needs of farmers and the actual information that is provided. The lack of co-production between producers and users is a significant factor in this problem, and where this cooperation lacks, user needs are hardly met.

## 2.3 Importance of weather information on farmers livelihoods and decision-making

Weather information importance in meeting user needs has been well documented. Studies on the relative importance of weather information on farmers management decisions and livelihoods have been conducted in developing countries (Feleke, 2015). A study conducted in Burkina Faso reported that the relative importance of weather information is influenced by agricultural strategies and crop requirements (Ingram *et al.,* 2002).

For example, in southwest Burkina Faso, crops are vulnerable to water stresses therefore, weather information on water deficit periods allows farmers to plant when water stress levels have improved, and the crops are less vulnerable to the conditions. In western Kenya, Onyango *et al. (*2014) found that weather information is important for risk management and pest and disease management. Furthermore, Bachhav (2012) states that information that meets the needs of farmers helps them to make well-informed decisions based on weather trends on crops to plant and the time of plantation.

In South Africa, weather forecasts that predict low rainfall could allow farmers to engage in conservation agriculture as this method favors soil moisture through rotation, mulching, and minimum tillage (Thierfelder *et al.,* 2016). According to Twomlow *et al.* (2006), the time horizon of weather and seasonal forecasts is an important aspect that influences decision time. With a seasonal forecast, farmers can decide on a crop variety if the season is expected to be dryer or wetter but cannot do so with a weather forecast (Selato, 2017). Seasonal forecasts can allow farmers to sow long seasonal hybrid crops as these can maximize conditions and result in higher yields. However, with weather forecasts, Cooper *et al.* (2008) have found that this information is important as it prompts farmers to make decisions that minimize damage to crops. Weather forecasts can allow farmers to decide on the irrigation and fertilization amount.

# Chapter 3: Methodology

This chapter describes the methods used in this study to capture and analyze the data in detail. Firstly, the climate and agricultural activities of the Eastern Cape province are presented. The study area level is further narrowed down to the municipality and study area level which is Maclear. In this study, Maclear is used as a proxy of the Eastern Cape province. The population demographics, climate and agricultural activities of Maclear are outlined. The chapter also outlines the methods of data collection and analysis. Lastly, this chapter outlines the ethical considerations of the study.

## 3.1 Study area description

### 3.1.1 Description of the Eastern Cape Province

Eastern Cape is predominantly rural, it is characterized by high poverty levels as 70.6% of the population is poor, and mostly relies on government support (Stats Sa, 2017). The province is 170 000 square kilometers in size and covers 13.9% of South Africa's land area (Jordaan, 2017). The province borders Kwazulu-Natal, Lesotho, Free State, Northern Cape, and the Western Cape province to the west. The southern and eastern borders of the province are formed by the Indian ocean (Figure1).

The province has temperate forests and is semi-arid with coastlines to the south and east (Jordaan, 2017). It is characterized by a range of climates which include a mild warm climate along the coastal zones that are in contrast with the hot and dry inland conditions. Winters are generally mild with average temperatures ranging from 7-20°C and summers are usually warm with average temperatures ranging from 16-29°C. Rainfall varies within the regions. The southern-eastern region experiences winter rainfall and the rest of the province experiences summer rainfall. Furthermore, the north-eastern coastal zone receives more than 1000 mm per annum, and the western region receives less than 400 mm (SAWS, 2012).


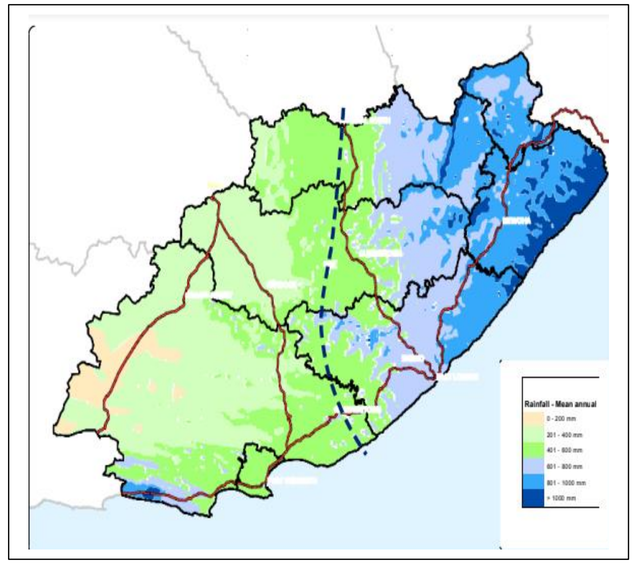


Figure 1:Satellite image of the Eastern Cape Province showing the southern and eastern borders (Source: Google earth) (left) and mean annual precipitation of the Eastern cape province (Source: SAWS, 2012) (right).

Within the province, agriculture is the most important activity (Jordaan, 2017). Most of the farmers are involved in crop farming and livestock production, and the province has the second largest number of smallholder farmers (DAFF, 2017). However, a significant proportion of the farmers are resource constrained.

### 3.1.2 Maclear area description

Maclear is located within the Elundini local municipality, which is situated within the Joe Gqabi District in the north-eastern part of the Eastern Cape province at 31.0791 S, 28.3556 E at an altitude of 1 272m (Du Plessis *et al.,* 2020) (Figure 2). The Joe Gqabi district receives a mean annual rainfall that ranges from 800- 1200 mm in the high-altitude area (Jordaan,2017). Most of the rain is a result of the westerly troughs and cut-off-lows in the upper atmosphere. The municipality has a semi-arid climate, temperatures range from 17.3-30.2 °C in summer and 6.3-21.8 °C in winter (Ngorima & Shackleton, 2019). The temperature can go as low as 5°C in July, which is the coldest month. Overall, the municipality receives an annual rainfall of 386 mm, mostly in summer from October to April.

Similar to the climate of Elundini municipality, Maclear has warm and wet summers, while winters are cold and dry (Jordaan,2017). The wet season is from October to April, and February is the wettest month. The town experiences seasonal variation in rainfall. Most of the rainfall is received in summer as opposed to the winter which is usually dry.

The dominant land use type within the municipality is agriculture, with a large population of smallholder farmers. According to Stats Sa (2011), about 15,209 households in the municipality are involved in agricultural activities. The main farming activities include sheep, goats, cattle, and crop farming. Maize production is high and plays a positive role in food security. High rainfall within the Elundini municipality increases the potential of maize production (Jordaan, 2017). However, access to resources to advance agricultural activities is limited. This is the case in Maclear where most smallholder farmers do not have access to financial resources for farming activities. Internet access is low which can play a role in limiting access to weather information. According to Stats Sa (2021), 79.2% of the population in Maclear has no access to the internet, 85% have access to a cellphone, 45.3% a radio, 69.4% a television, and 10.2% a computer.

In terms of the population size, according to Stats Sa (2011), Maclear has a total population of 8 559 people. Within the area, 69% of the population is the working age group (15-64), and only 5.2% are elderly (65+). Levels of formal employment within the town are low, and many households are reliant on government social grants (Ngorima & Shackleton, 2019). Most of the population (91.6%) in Maclear is made up of Blacks, 5.2% Coloreds, 2.4% Whites, and 0.4% Other. As a result, 86.6% of the population speaks IsiXhosa, 3.1% English, and 2.1% Sesotho. In terms of gender distribution, majority of the population is female (52.3%) and 47.7% male. About (46.8%) of the households are headed by females. Educational level is low, as most of the population (30.1%) has a secondary education, 16.4% have matric, and only 8.6% have a higher tertiary education level. The main economic activities in Maclear include social services and agriculture (Ngorima & Shackleton, 2019).

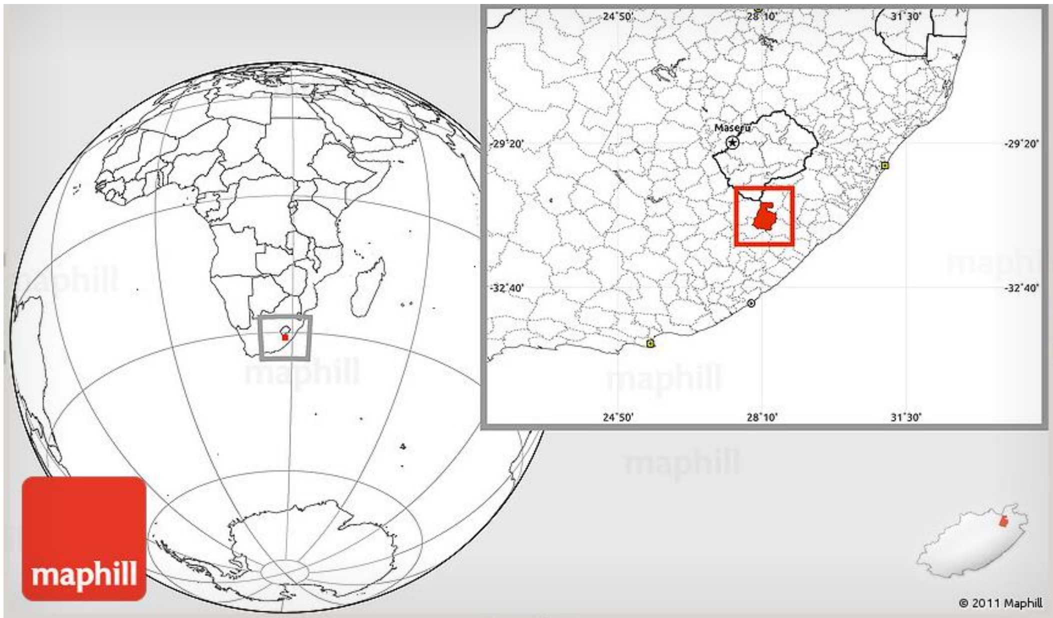


Figure 2:Map showing Maclear, highlighted in red (Source: Maphill, 2011).

## 3.2 Material and methods

This study employed a mixed-methods approach where qualitative and quantitative methods were used. Interviews with open-ended and closed-ended questions were conducted to gather qualitative and quantitative data. The mixed-methods approach was used because it can yield more comprehensive and useful data, something that a quantitative or qualitative approach cannot achieve alone (Yu, 2009). This approach has its advantages. It provides more robust evidence to make an accurate conclusion on research objectives. It allows for qualitative and quantitative data to validate each other and provides a broader spectrum for better understanding problems and different contexts (Creswell & Clark, 2017). Additionally, it allows data to be displayed in various forms such as graphs, percentages, numbers, and narratives. This approach helps in better understanding the data.

### 3.2.1 Sampling

The population of focus in this study was smallholder farmers, and only farmers that identify as smallholder farmers were selected. A random sampling technique was used to select the farmers, where farmers were selected randomly. This technique was used because it is unbiased and gives a good representation of the population where each member has an equal chance of being chosen (Benard *et al.,* 2014). Initially, a total of 60 participants were aimed to be selected for data collection, and this process was allocated a time period of a week. However, due to the limited availability of farmers, the target sample size of 60 farmers was unfortunately not met. Therefore, data was only collected from 29 farmers. The sample size was not meant to represent the Eastern Cape province, but Maclear as a study area. Maclear was used as a proxy of the Eastern Cape province. The farmers were selected randomly using a listing of the villages in Maclear, which included the farmers contact details. The list was obtained from Grain SA, a project in Kokstad that focuses on making a difference in the agricultural sector. Farmers were selected from five villages in Maclear. These villages were Katkop 1, Tsekong, Kohlopong, Lubalweni, and Ngqayi. The number of farmers selected in the villages varied, and this depended on farmers availability and accessibility, as some areas were inaccessible due to flooding of the roads. The process of randomly selecting the farmers allowed the study to be diverse in terms of responses as farmers needs vary depending on their everyday challenges, needs, contexts, age, gender, education level, and experienced weather conditions.

In the study, three agricultural extension officers were also interviewed. This is because they have a knowledgeable background on the needs of smallholder farmers, as they constantly interact and engage with them. The other reason for including extension officers is that there is a need to understand agricultural extension officers needs as this can also bring forth differences between extension officers needs and smallholder farmers. These can help better inform farmers and extension officers weather information needs in terms of improvement.

### 3.2.2 Data collection

A set of questions were prepared before the fieldwork, and practice rounds with friends and family were conducted to increase familiarization with the questions and flow to prevent any gaps associated with misunderstanding questions or terms used. Data was collected in person from the 6th to the 12th of February 2022. The primary data of the study was collected from both smallholder farmers and agricultural extension officers. The questions for farmers and extension officers were separated but were similar. Data was collected from extension officers to note differences and similarities with farmers responses and for a better understanding of the weather information received and needed as officers work closely with farmers and are a closer form of aid to farmers. Before going to the field, farmers and agricultural extension officers were contacted through a phone call to explain the research project. The benefits of the research in terms of feedback were also communicated. Additionally, participants availability, and willingness to participate in the study was confirmed with the farmers and agricultural extension officers.

Interviews with open-ended and closed-ended questions were conducted to gather information on the weather information needs of smallholder farmers (annex 1) and agricultural extension officers (annex 2). An audio recorder was used to record the responses of the participants. The questions were divided into three sections. The first section had questions about the baseline weather information and information characteristics received. The questions included the type of weather information received, the source, format, and frequency in which the information is received, decisions made with the information, challenges associated with using the information, and ways of improving use. The second section was designed to investigate the kind of weather information needed and how it can be improved and better communicated in terms of format, language, source, frequency to increase use, and whether the information can help make better decisions and why. The third section in annex 1 covered the demographic information of the farmers.

Interviews were conducted in the language farmers, and extension officers preferred and understood. In this case, the interviews were conducted in IsiXhosa for easy communication and understanding of the questions, as most of the farmers and extension officers are Xhosa speakers. The questions were translated from English into IsiXhosa by myself as a Xhosa speaker. Farmers and agricultural extension officers of all age groups and gender were interviewed.

The interviews were conversational and gave the participants room to share their ideas, views, and experiences. Some of the questions that the farmers and extension officers were asked included questions such as (1) What kind of weather information the participants need and why, and also (2) How the use of weather information can be improved. These questions allowed the participants to give more details on the questions asked (Guion *et al.,* 2011). Open-ended questions allowed farmers to express themselves without any limitations. Lorenzoni *et al.* (2007) stress that qualitative methods can unravel why people view things a certain way and what influences them and their choices. The information collected from the participants was archived for further analysis and the write up process.

### 3.2.3 Data analysis

Consistent with the mixed methods approach, qualitative and quantitative data analysis techniques were used to analyze the data. Quantitative data was analyzed using Microsoft Excel to draw descriptive statistics. Qualitative data was analyzed using thematic analysis, where emerging themes were identified from the participants responses. Thematic analysis was used in the study because it is a foundational method for qualitative analysis, as it allows data to be analyzed according to themes for better understanding and further exploration (Braun & Clarke, 2006). In the study, the archived audio data was transcribed in Microsoft Excel for analysis. In cases of clarity and deeper understanding, the audios were listened to repeatedly. Even though the interviews were conducted in IsiXhosa, the participants responses were transcribed in Microsoft Excel in English. Only the information relevant to the study was transcribed in Excel. Farmers responses were further analyzed and calculated using simple statistics to determine the number of farmers saying the same thing or different things. In calculating the simple statistics for the open-ended and closed-ended questions, percentages were calculated for each question according to the number of times the respondents mentioned a particular response out of the total number of farmers interviewed, which was 29. The same was done for extension officers. The questions allowed the farmers and extension officers to choose more than one option, therefore the percentage was more than 100% in most cases. For presentation purposes, data was presented in graphs and tables.

## 3.3 Ethics approval and consent

The study ethics application was submitted to the University of Cape Town Faculty of Science research ethics committee to meet the ethical standards of the committee. The ethics application was approved [FSREC 004 – 2022]. A brief introduction of the research was presented to the study's participants to enable understanding of the study and to create room for any questions participants may have. All the participants were informed of the nature of the research, its aim, and its benefits. Informed consent was obtained in person in the form of a signed consent form where forms were issued to the farmers and agricultural extension officers before the interviews started. Participants were also assured that confidentiality will be maintained, and the information will not be shared with anyone.

# Chapter 4: Results

This chapter presents the key findings of the study. Firstly, the demographic information of the farmers is presented, followed by the baseline and characteristics of weather information smallholder farmers receive. The following section presents the use and importance of weather information on farmers agricultural practices and decision-making process. This is followed by a section on the acceptance/ use of weather information, and farmers suggestions on ways to improve weather information use and understanding. Furthermore, weather information needs of the farmers are outlined. Lastly, perceptions of agricultural extension officers regarding weather information farmers and extension officers receive plus their needs are presented.

## 4.1 Demographic profile

The demographic information of the interviewed smallholder farmers is presented in Table 1. A total of 29 farmers were interviewed. Most of the participants were from Tsekong (38%), with only 7% of the participants from Kohlopong. Over 60% of participants had more than 10 years of farming experience. Household size varied, where 83% of the participants had households of about 1-5 individuals which are a combination of individuals that are active and non-active in farming. Most of the households (62%) were headed by females and 38% male. No implication was made by the farmers on whether these households are single-headed or not. On the basis of gender, 20 of the participants were female (69%), and 9 (31%) were male. The participants educational level indicated a low education status, 35% had a primary education, 41% secondary education, and 21% matric. Only 3% had a tertiary education. Females had the lowest education level compared to the male farmers. Out of the 20 interviewed females, 8 (40%) of the female farmers had a primary education, 8 (40%) had a secondary education with only 4 (20%) with the highest education level, which was matric. Only 2 out of 9 (22%) of the male farmers had a primary education, 4 (44%) with a secondary education, 2 (22%) with a matric and only one (3%) indicated having a tertiary education. Most of the farmers (59%) were between the ages of 35-60, and 21% had a primary education, 24% had a secondary education, and 14% had a matric. 34% of the farmers were elderly (over the age of 60), and 14% of the farmers had a primary education,17% a secondary education, and 3% had matric. Only two male farmers (7%) were between the age of 18-35, one had a matric and the other a tertiary education. In terms of the employment status, the unemployment rate was high, 59% of the participants were unemployed, 31% were pensioners, and only 10% were employed. The employed farmers are involved in off-farm activities. Majority of the unemployed participants were female (34%), mainly relying on crop farming for an income. Crop farming was the primary source of income for the farmers through selling maize and vegetables such as onions, potatoes, tomatoes, and carrots. At the same time, only 17% of the farmers indicated livestock farming as a source of income. Most of the farmers mentioned that they no longer own livestock such as cows and sheep because of high livestock theft and the danger theft brings to their lives.

Table 1: Demographic profile of farmers (n=29)

| **Demographic profile** | **Categories** | **Frequency** | **Percentage (%)** |
|---|---|---|---|
| Village location | Tsekong | 11 | 38 |
| | Lubalweni | 8 | 28 |
| | Ngqayi | 5 | 17 |
| | Katkop 1 | 3 | 10 |
| | Kohlopong | 2 | 7 |
| Farming experience | 0-5 | 3 | 10 |
| | 5-10 | 8 | 28 |
| | >10 | 18 | 62 |
| Household size | 1-5 | 24 | 83 |
| | 6-10 | 4 | 14 |
| | >10 | 1 | 3 |
| Household head | Female | 18 | 62 |
| | Male | 11 | 38 |
| Employment status | Unemployed | 17 | 59 |
| | Pensioner | 9 | 31 |
| | Employed | 3 | 10 |
| Gender | Female | 20 | 69 |
| | Male | 9 | 31 |
| Age | 18-35 | 2 | 7 |
| | 35-60 | 17 | 59 |
| | ><60 | 10 | 34 |
| Education level | Primary | 10 | 35 |
| | Secondary | 12 | 41 |
| | Matric | 6 | 21 |
| | Tertiary | 1 | 3 |
| Source of income | Crop farming | 18 | 62 |
| | Off-farm activities | 6 | 21 |
| | Livestock farming | 5 | 17 |

## 4.2 Baseline weather information farmers receive and its characteristics

### 4.2.1 Type of weather information farmers receive

Farmers were asked questions relating to the baseline weather information they receive. This information is used as a baseline for this study. Firstly, the farmers were asked whether they receive weather information, and all of them mentioned they do. The follow-up question looked at the type of weather information the farmers receive. The farmers were presented with a set of options to choose from but were also not restricted to the options provided to them. This was to ensure that all responses covered the type of information farmers receive. The interview questions allowed the farmers to choose more than one option therefore, the percentage sum is greater than 100%. All the chosen options are presented in (Figure 3). The most mentioned types of weather information that farmers receive are rainfall (97%), temperature (97%), and heavy rain (34%). The results presented in (Figure 3) show that farmers receive a wide range of weather information, but a few farmers receive information on hailstorms and thunderstorms. The results show that certain types of weather information are more prominent than the other types.

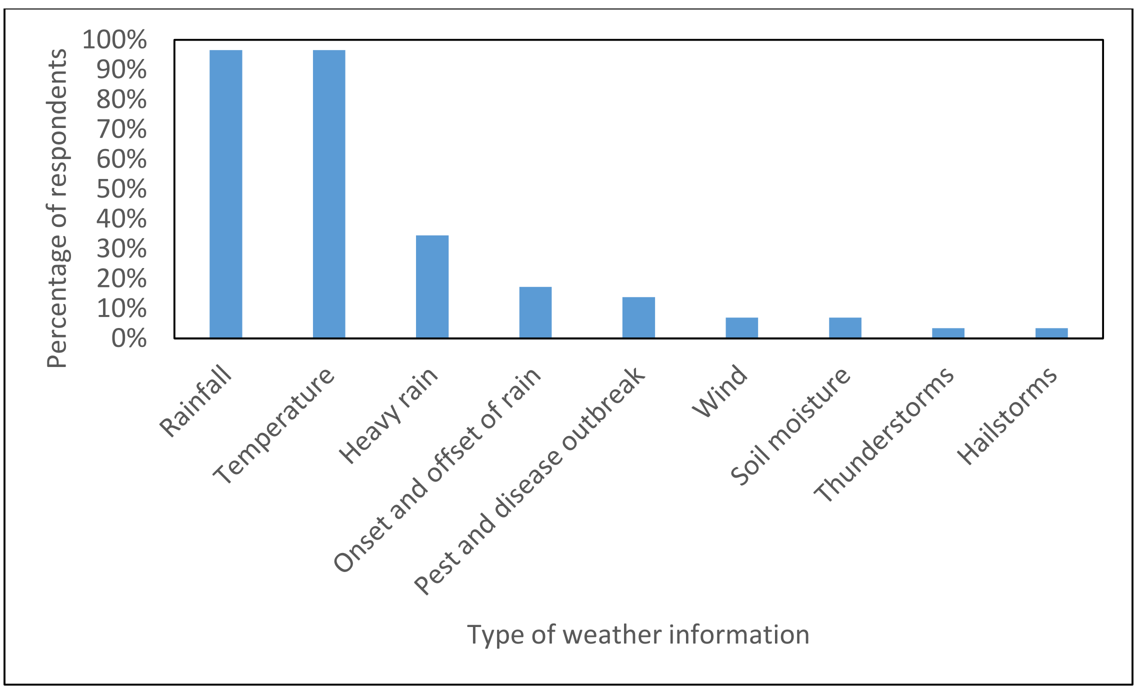


Figure 3: Type of weather information farmers receive.

### 4.2.2 Source of weather information

Establishing the source from which farmers receive weather information is important to understand where farmers receive information. Farmers were asked where they receive weather information. Farmers were presented with a number of options to choose from but were not limited to the options presented to them, and these are displayed in (Figure 4). The farmers were encouraged to select every source they receive weather information from and were allowed to choose more than one option. As shown in (Figure 4) below, farmers receive weather information from several different sources. The most popular sources of weather information include television (97%) and radio (67%). Farmers mentioned that from the television, they receive heavy rainfall, rainfall, wind, temperature, and thunderstorm information. On the radio, they receive rainfall, temperature, pest and disease outbreak information. The farmers expressed that they receive weather information from the television and radio daily. On these major sources of information, none of the farmers mentioned receiving weather information weekly, monthly, or seasonally. The farmers also expressed that they are satisfied with how frequently they received the information as it assists with their day-to-day farming activities and planning.

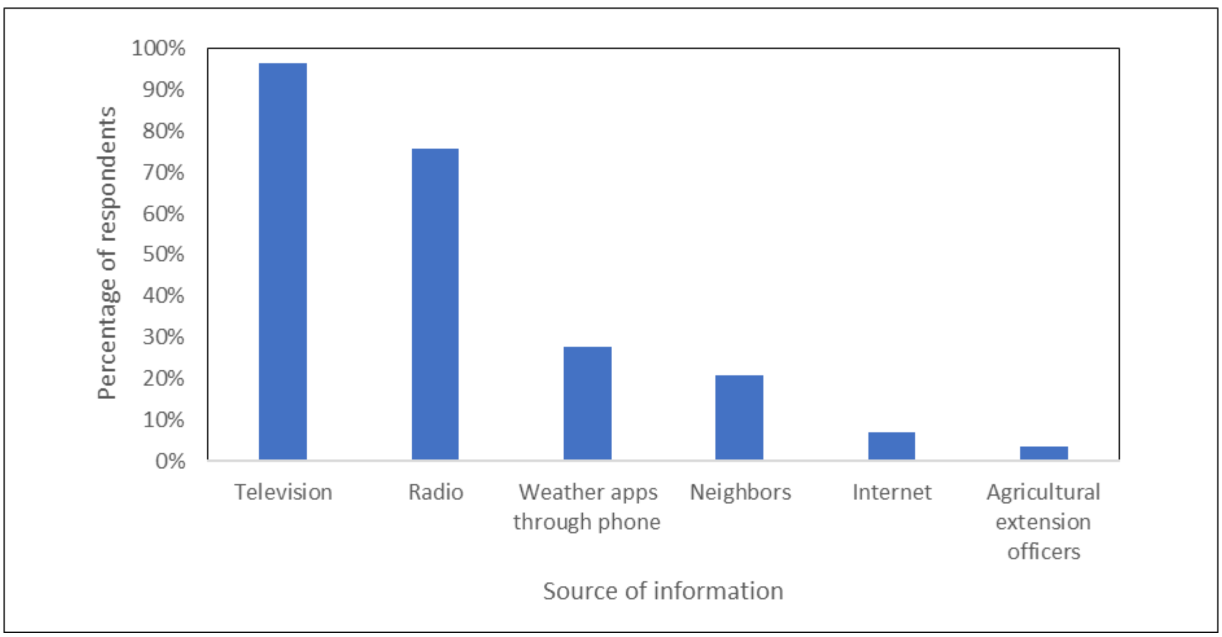


Figure 4: Sources of weather information.

Weather information from the television is from the South African Broadcasting Corporation (SABC), which receives the information from the SAWS. The SAWS is the only source provider of weather information for the SABC in South Africa. Weather apps (28%), neighbors (21%), internet (7%), and agricultural extension officers (3%) are also important sources in which farmers receive weather information, despite the limited mentions of these sources. The farmers related limited reception of weather information from weather apps and the internet to limited accessibility of resources such as smartphones, computers, and internet data. They also pointed out the effect of their low education level on their understanding and use of these sources.

From weather apps, farmers mentioned that they receive rainfall, temperature, and thunderstorm information, while on the internet, they receive rainfall, heavy rainfall, temperature, wind, and thunderstorm information. Interestingly, there were differences between the source of information and age. Most of the farmers aged between 35-60 and 60 above mostly receive their weather information from the television and radio, but there were only seven farmers aged between 35-60 that receive their weather information from weather apps. Only one elderly female farmer (above 60 in age) mentioned receiving weather information from weather apps. All the young farmers mentioned that they receive weather information mostly from weather apps and the internet. All the farmers that receive weather information from weather apps expressed that they access the information from AccuWeather https://www.accuweather.com/ at any time of the day.

Regarding social networks, 21% of the farmers mentioned receiving weather information from neighbors through random interactions. They also noted that this information is mostly based on farmers experiences and indigenous knowledge passed down through generations. The farmers stressed that they use their indigenous knowledge from farming experiences and knowledge to predict weather conditions. The farmers further expressed that neighbors play an important role in knowing how the weather conditions will be. Weather information that farmers receive from neighbors include rainfall, temperature, thunderstorm, and wind information. Farmers mentioned that this information is important for their day-to-day activities and farming activities. As a result, neighbors seem to be an important source of weather information that has a positive impact in terms of sharing weather information. The houses of the farmers in the visited villages were near each other therefore, neighbors are easily accessible, and this can play a positive role in farmers easily sharing weather information with each other.

To understand whether farmers have always received weather information or not. Farmers were asked whether they received weather information before, from where and if not, why. The farmers could choose more than one response regarding where they received the information. Interestingly most of the farmers (66%) mentioned that they received weather information before. Most of the farmers (59%) received the information from neighbors and only 14% from radio. However, 34% of the farmers mentioned they did not receive weather information before. They indicated that this is because of a lack of access to resources such as television and radio.

Furthermore, most of the farmers reported that before having access to television and radio, they relied on indigenous knowledge passed down from generations to predict weather conditions. The farmers expressed that neighbors are a major source of indigenous knowledge. The elderly farmers reported that they do not only use indigenous knowledge to predict weather conditions but also to inform their farming decisions in their everyday lives. Furthermore, it is worth mentioning that the elderly farmers mentioned that the indicators they use are of great help in their lives. Interestingly one female farmer stated that "indigenous knowledge indicators are important and are still relevant and applicable in our decision-making and lives till today." Most of the farmers, especially elderly farmers mentioned that they use a range of indigenous knowledge indicators such as the barn swallow bird, also referred to as iNkojane in IsiZulu, the presence of dew on the grass in the morning, the color of the clouds, and the direction the moon is facing. Interestingly, the farmers mentioned that the presence of the barn swallow indicates that weather conditions will be warm, and dew on the grass in the morning indicates warm conditions. Dark clouds were mentioned to be an indication that it will rain, and the direction in which the moon is facing was mentioned to indicate different weather conditions. The farmers mentioned that when the moon is facing towards the right, this is an indication that there will be windy conditions, facing upwards this is an indication of warm conditions, and lastly, when facing downwards, this is an indication that it will rain. These results show that indigenous knowledge indicators help farmers to predict different weather conditions that can have a positive impact in their farming practices and decision-making. With these results, there was no significant difference in terms of indigenous knowledge use by gender. However, there was a difference with age as most of the young farmers indicated using the internet to predict weather conditions compared to the elderly farmers. The above-mentioned indigenous knowledge indicators suggest that indigenous knowledge indicators play a vital role in agriculture in terms of making farmers aware of weather conditions and informing farmers decision-making.

### 4.2.3 Format of weather information

The farmers mentioned that they receive weather information in a range of formats (Figure 5), and 97% of the farmers responded that they receive the information in maps, 55% in audio, 24% in images, and only 7% in text. 66% of farmers receive weather information from more than one format and 34% receive weather information from one format. From maps, farmers mentioned that they receive maximum and minimum temperatures of the day and night, and the probability of rainfall. Farmers found maps to be helpful in understanding weather information than other formats as they stated that the information is easy to visualize. Despite having maps favored, the farmers expressed that all the formats in which they receive weather information do not cover their local scale, which leads to decisions with a higher risk in their contexts. For example, the farmers mentioned that maps cover a larger scale and show weather information for the nearest towns far from them, such as Umtata, which is about 111. 8 km away. This finding shows that in cases when temperatures are estimated to be warm farmers would start preparing for planting and start planting only to find out the following day that it is raining, which would damage their crops and vegetables.

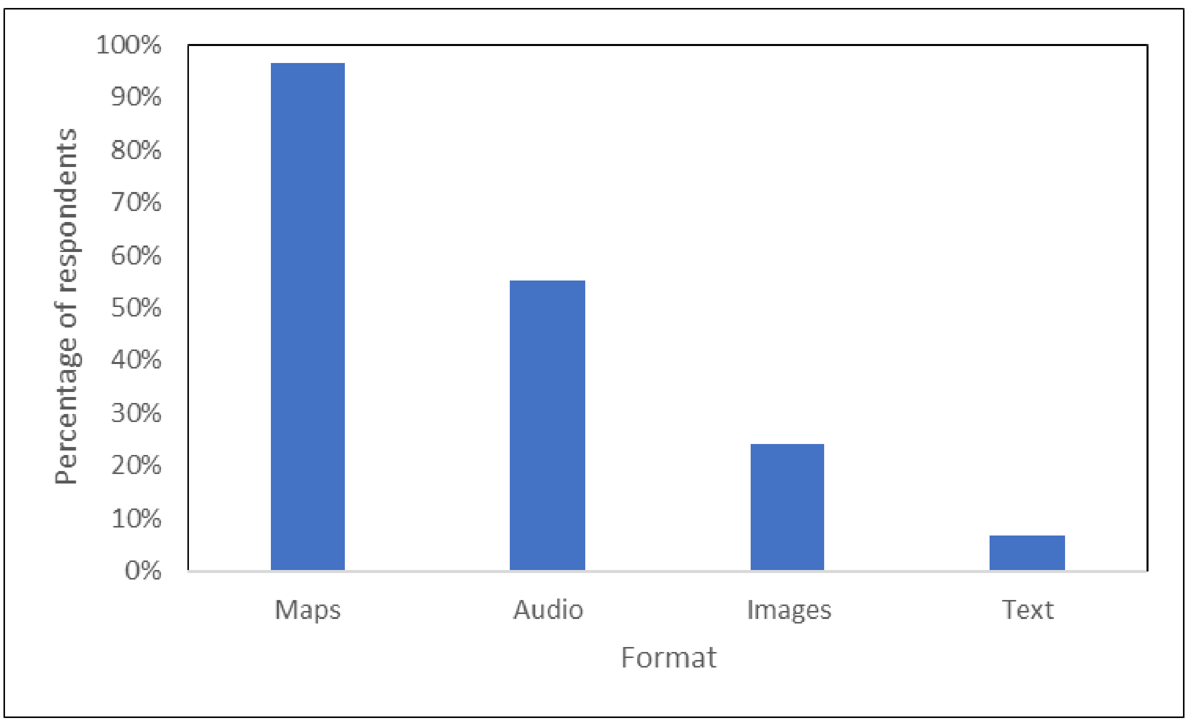


Figure 5: Format farmers receive weather information.

Farmers that receive weather information in maps and audio, 97% of them expressed they receive the information in IsiXhosa, and 17% in IsiZulu. The farmers mentioned that they mostly receive weather information in IsiXhosa because it is their local language, and it is easy to understand. They also expressed that their kids also understand IsiXhosa which is helpful on their behalf as kids can share the information with the elders in cases where the elders are busy and cannot receive the information at the time it was communicated on the television or radio. All the farmers that receive weather information on weather apps indicated that they receive the information in images, text and maps in English. As mentioned above on the sources of information the Accuweather app is the main weather app in which farmers receive weather information, and the information is presented in English. English is the only language that applies in the South African context and can be understood as other languages are foreign. However, in the context of the farmers IsiXhosa is the local language, and this may have some implications in understanding the information. Moreover, one female farmer expressed that she receives weather information in Sesotho, and she stated that she grew up in a household that speaks Sesotho therefore she understands the language better.

### 4.2.4 Use and importance of weather information to farmers

All the farmers mentioned that the information they receive is useful and important in their farming activities and decision-making. Rainfall and temperature were considered to be important, as the farmers noted that they grow vegetables and crops that rely on rainfall and warm temperatures. Even though wind, thunderstorm and hailstorm information were mentioned a few times by the farmers, this information was found to be of much less importance by the farmers as they stated that there is not much they can do with it, and that it does not have much of an influence on their decision-making and farming activities. The farmers mentioned that they use the weather information they receive to make decisions that positively impact their farming activities (Figure 6). The farming decisions made by the farmers varied. Most of the farmers (79%) mentioned they use rainfall, temperature, and heavy rainfall information to know when to plant crops and vegetables. Also, 45% of the farmers said they use the information on pest and disease outbreaks and rainfall to know the best appropriate time for harvesting crops and vegetables. For example, the farmers mentioned that vegetables such as potatoes and tomatoes get damaged when there is a lot of rain. As a result, the farmers use the information on heavy rainfall and rain to plan for the best appropriate time for harvesting. With this information, only 7% of the farmers mentioned using rainfall information for land preparation, especially during the wet season when maize is set to be planted. Farmers also mentioned using this information to plan for the best time for applying fertilizers and herbicides.

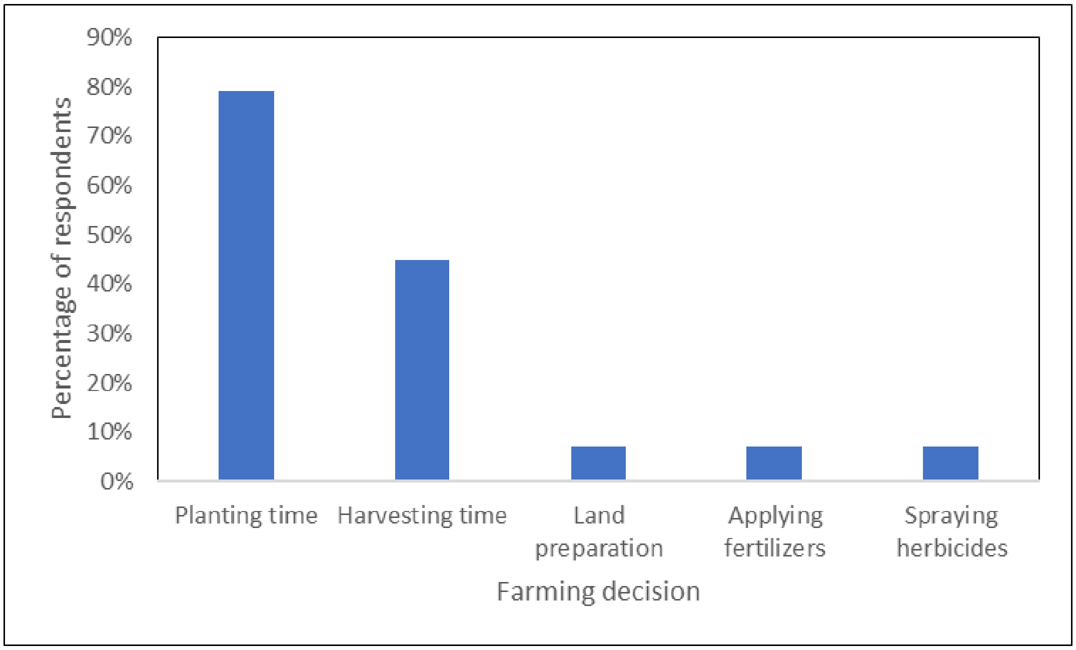


Figure 6: Farming decisions made by farmers from weather information they receive.

## 4.3 Acceptance/use of weather information

With all the farmers receiving weather information, it was interesting to discover whether there are some instances they never use the information they receive and their reasons as to why. This finding would not only allow for a deeper understanding but would help in discovering gaps that need to be improved with weather information dissemination. Farmers were encouraged to state as many reasons as to why they sometimes do not use weather information. Despite receiving weather information, farmers stated that they sometimes do not use the information for various reasons, but they did not go into detail with all the reasons (Table 2). Most of the respondents (97%) reported that the information they receive is sometimes inaccurate. The farmers mostly expressed that in the summer season of December 2021, the weather information they received was inaccurate and misleading as the information had no signs or warnings of heavy rain, but throughout the summer period, they experienced heavy rain that damaged their crops and vegetables which resulted in income and food losses.

Table 2: Farmers reasons for not using weather information despite receiving it (n=29).

| **Reason for not using weather information** | **Response percentage (%)** |
|---|---|
| Information sometimes inaccurate | 97 |
| Information unreliable and can be misleading | 10 |
| Lack of trust in the information | 7 |
| Lack of understanding | 3 |

To improve the use of weather information among farmers, they were asked to suggest ways to improve weather information that can allow them to better understand and use the information. All the farmers suggested that they would like to get training to better understand and use weather information to improve their decision-making and farming practices. A few of the farmers also expressed the need to downscale weather information to their local scale as the current weather information system does not cover their local context which can sometimes be misleading.

## 4.4 Weather information needs of farmers

### 4.4.1 Better type of weather information

Farmers type of weather information needed (Figure 7) shifted from the baseline information they are receiving, except for rainfall and heavy rain. Most of the farmers (83%) indicated they would like to receive information on drought, 55% on heavy rain, and 21% on rain. The farmers valued the information for their farming decisions. The farmers mentioned that drought information would help them know which crops and vegetables to plant and when, to prevent crop and financial losses as they are currently experiencing dry periods and a water scarcity problem. Furthermore, the farmers mentioned that they need heavy rain information. The farmers expressed that heavy rainfall information can help them plan on time, prevent losses, and know when to plant, as vegetables such as potatoes and tomatoes are an important source of income. The identified weather information that farmers need and the decisions they could make show the importance of this information in aiding farmers towards enhanced farming practices and reduced risk.

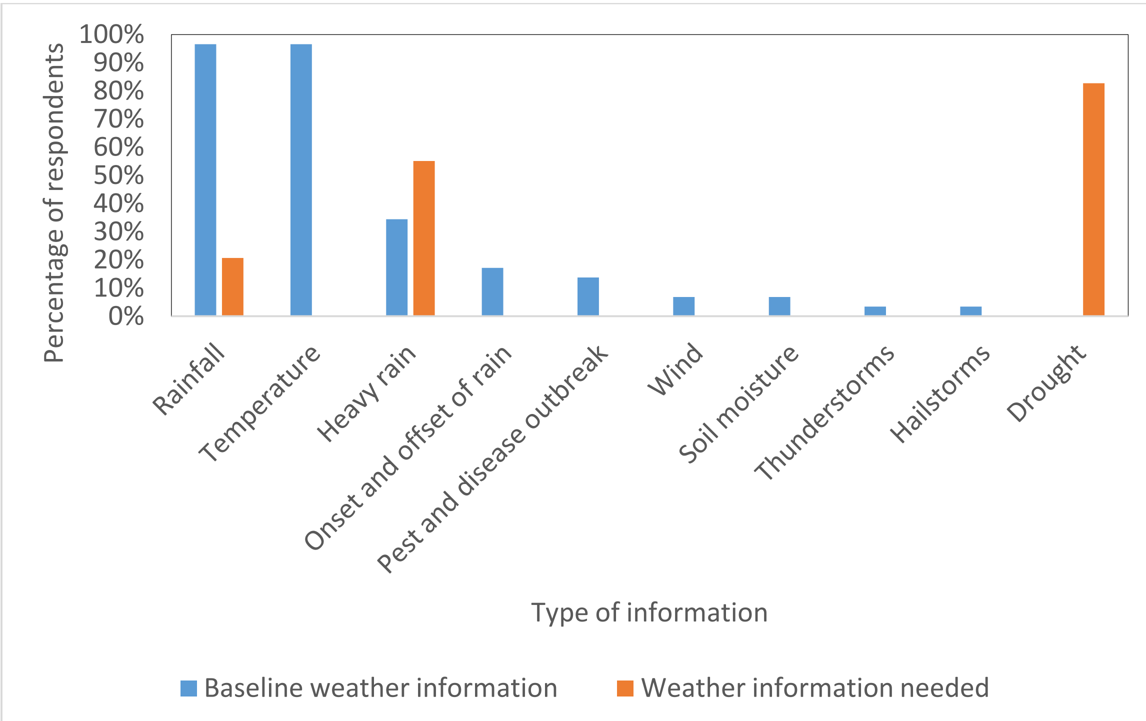


Figure 7: Comparison between the baseline weather information farmers receive and the weather information they need.

To better understand the needs of farmers. Farmers were asked which language and source they would prefer to receive weather information. All the farmers expressed that they would like to receive weather information in IsiXhosa because it is their local language and is easy to understand. Television ranked highest as the preferred source of information (86%), while 24% of the respondents indicated they preferred radio (Figure 8). Farmers could prefer the television and radio because they communicate information in IsiXhosa. For example, the older farmers expressed that they prefer to receive information from the radio because it is communicated frequently in the local language, which makes it easy for them to understand. Only 7% preferred the internet, and it was the young farmers. Farmers stated they mostly prefer the television because the information is communicated daily in the form of maps, which show the minimum and maximum temperatures of the day and night, a better geographical resolution of their area of interest, and is easy to visualize and understand. The young farmers (7%) preferred to receive information from the internet in the form of images and maps. They mentioned that information received in images allows them to zoom in and out to get a better view of the information displayed. They further mentioned that the internet allows for easy accessibility and has the convenience of being able to view weather information of an area of preference at any time of the day.

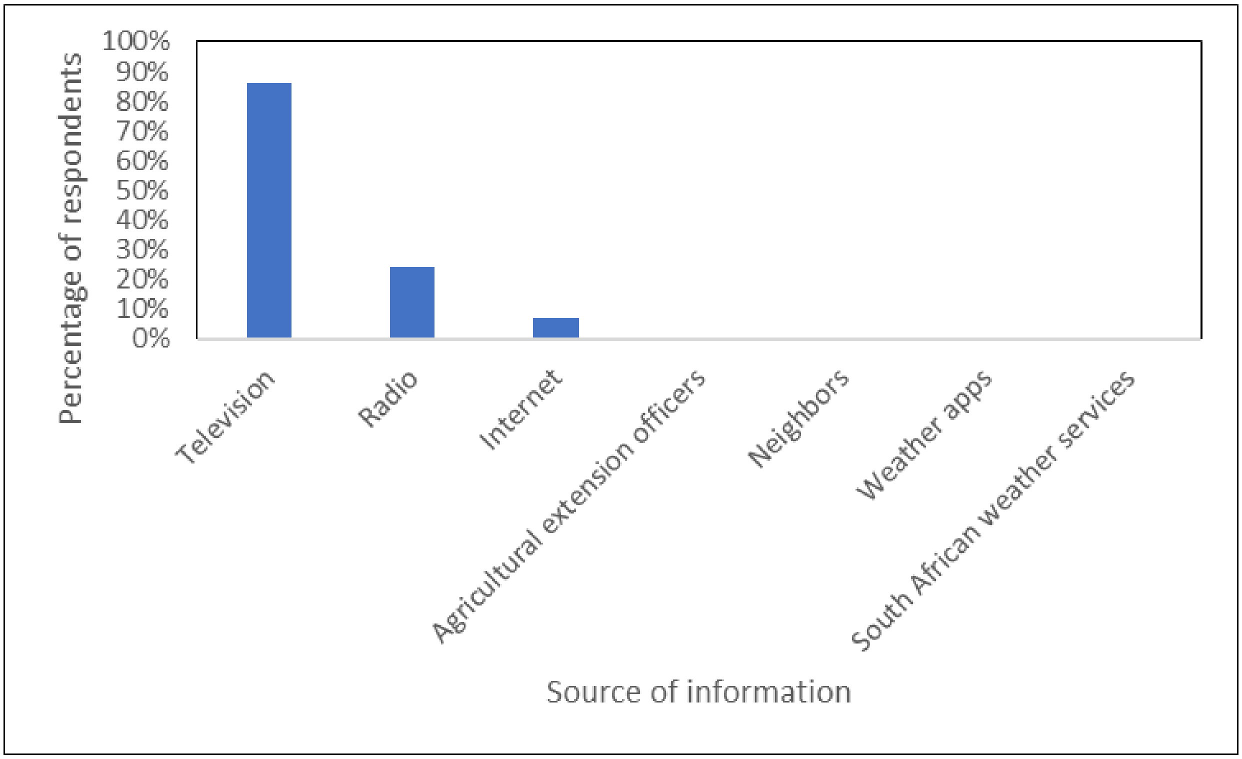


Figure 8: Sources preferred by farmers to receive weather information.

### 4.4.2 Better frequency to receive weather information

More than half (79%) of the farmers were interested in receiving weather information daily to better plan their farming activities and to make well-informed decisions on the best times to plant crops and vegetables (Figure 9). However, 21% of farmers were interested in receiving information weekly, 7% seasonally, and 3% monthly. Farmers expressed that they would like to receive information weekly so they can know how the week ahead will be so they can plan on time. A few farmers were keen on receiving information monthly as they believed this could help in planning a month ahead. The farmers that would like to receive information seasonally shared the same views on better planning their farming activities. The farmers mentioned they are keen on receiving information seasonally to know if it will be dry or wet in the upcoming season. Farmers also mentioned that this could help them to know which crops to plant as some crops, such as maize, thrive better in wet summer conditions.

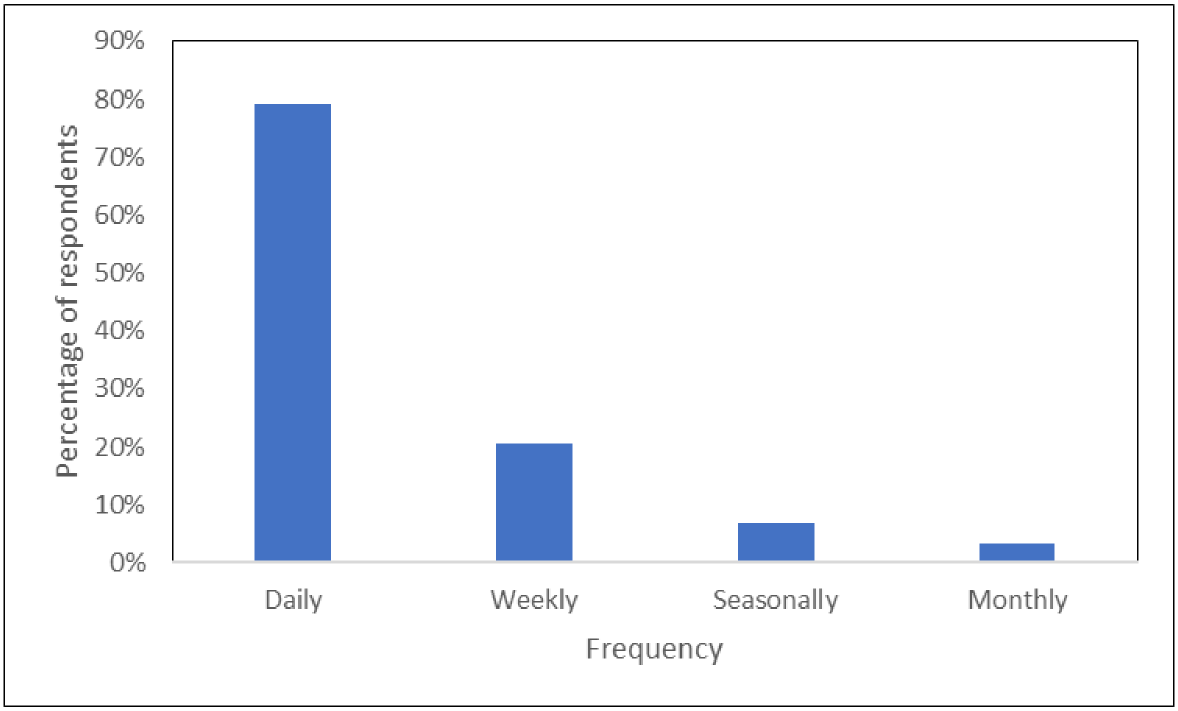


Figure 9: Better frequency farmers would prefer to receive weather information.

## 4.5 Agricultural extension officers perceptions of farmers and extension officers needs

Three agricultural extension officers were interviewed. There was only a limited number of extension officers that were interviewed because these were the only extension officers that were available at the time interviews were being conducted. Interviews with the agricultural extension officers allowed for a comparison with farmers responses. The extension officers were asked questions on farmers baseline weather information, needs, and improvement of weather information. Firstly, extension officers were asked about the type of weather information farmers receive and its characteristics in terms of source, format, language, and frequency. The officers were encouraged to state as many types of weather information that farmers receive and characteristics. All the extension officers mentioned that farmers receive rainfall, temperature, and heavy rainfall information daily from the television, radio, weather apps, and neighbors. They expressed that farmers receive weather information from the television and radio in maps and audio in IsiXhosa. On weather apps, they said farmers receive weather information only in the form of maps in English. Then from neighbors, they mentioned that farmers receive the information through speech in IsiXhosa, which is from conversations farmers have with each other as they live near each other.

As a follow-up, agricultural extension officers were asked questions relating to the needs of farmers in terms of the type of information they think farmers need, the source, format, frequency, and language. Extension officers expressed that farmers need drought and heavy rainfall information, as this information can help improve their decision-making during farming activities. They supported this by stating that this type of information can allow farmers to know when and what to plant, as Maclear is currently experiencing drought periods and sometimes heavy rainfall. Furthermore, regarding the preferred source, television was ranked highest, followed by extension officers as sources that would be best suitable for farmers to receive weather information. In terms of the format, agricultural extension officers mentioned that maps would be the most suitable format to receive weather information to farmers. They supported this by stating that maps are detailed, can show an area of interest, and are easy to visualize and understand. The language agricultural extension officers noted to be important to communicate the information is IsiXhosa because it is the farmers local language, and it will make it easy for the farmers to understand the information.

Understanding the baseline weather information extension officers receive and their needs was important to see whether there are differences or similarities with the farmers responses. The same questions that were asked to the extension officers about farmers above were asked about extension officers to get an understanding of the baseline information they receive and its characteristics and their needs to understand how they would prefer to receive weather information. Extension officers were asked if they receive weather information, the type of information they receive, and when and from where. All the extension officers mentioned that they receive rainfall, temperature, heavy rainfall, drought, and pest and disease outbreak information. All the extension officers mentioned that they receive weather information from Disaster, which is an office located in the Joe Gqabi Municipality District.

The officers expressed that they receive information from Disaster in the form of maps, text, and images weekly in English. However, one female officer mentioned that she receives the information seasonally, mostly in winter. Out of the three officers, one female officer mentioned receiving weather information from three sources which are; Disaster, the television, and radio. The extension officer expressed that from the television, she receives the information daily in the form of maps and audio in English.

Follow-up questions included questions related to the needs of extension officers. One female officer said she would like to receive information on drought and pest and disease outbreaks daily and seasonally. Interestingly, the officer expressed that she would like to receive the information seasonally to determine when there will be hailstorms in summer to warn the farmers on time as farmers farming activities usually get affected by hailstorms in summer. The remaining two officers preferred receiving only information on pest and disease outbreaks weekly. In support of receiving information on pest and disease outbreaks, all the officers mentioned that in the previous year (2021), farms were attacked by armyworms, which destroyed vegetables and crops. Therefore, in planning for attacks, the officers preferred receiving information about pests and diseases on time to warn farmers to prevent crops and vegetables from being damaged. All the officers preferred receiving information from Disaster because the information is detailed, reliable, informative, and up to date. They also preferred to receive the information in maps, and they expressed that maps are detailed and make it easy to visualize and understand the information presented. All the officers also preferred to receive the information in images, and they reasoned that images allow them to visualize presented weather conditions in detail. They also preferred to receive weather information in English, and they expressed that it is easy to understand the information in this language. Moreover, one male officer also preferred to receive the information in IsiXhosa. The officer expressed that IsiXhosa is his local language therefore, it also makes it easy for him to understand the information.

Lastly, extension officers were asked to state ways in which weather information can be improved to increase its understanding and use. Similar to the farmers responses, they expressed that farmers and officers need training to better understand the information. On their side, they expressed that officers experience challenges in effectively understanding the information. The results mentioned above compared to the farmers responses show that there are some differences and similarities in the information farmers receive compared to extension officers and with the needs. In addition, the results as presented in Table 3 show that the needs of farmers and extension officers, according to the perspective of extension officers, vary but are both towards the benefit of farmers.

Table 3: Weather information needs of farmers and agricultural extension officers according to the perspective of agricultural extension officers.

| | **Weather information needed** | **Preferred source of information** | **Preferred Format** | **Preferred frequency to receive information** | **Language** | **Decisions** | **Ways to improve use of weather information** |
|---|---|---|---|---|---|---|---|
| Farmers | Drought<br>Heavy rainfall | Television<br>Agricultural extension officers | Maps<br>Audio | Daily | IsiXhosa | -Can help farmers to be able to plan on time and prevent crop and livestock losses<br>-Can help farmers to know when to plant, and what to plant | Training farmers using their local language |
| Agricultural extension officers | Drought<br>Pest and disease outbreak | Disaster from the Joe Gqabi Municipality district | Images<br>Maps | Daily<br>seasonally<br>weekly | English<br>IsiXhosa | To warn farmers and advise them | Training extension officers |

# Chapter 5: Discussion

## 5.1 Efficiency of the current system

Most of the farmers in the study mentioned that they receive rainfall, temperature, and heavy rainfall information. This result could be that farmers have easy access to the above weather information compared to other types. Accessibility to information can also be attributed to the sources of information in the study area. Television and radio were the dominant sources of weather information. The popularity of television and radio as sources of information in South Africa has been associated with their ability to communicate weather information using understandable language (Ncoyini *et al.,* 2022). This finding was evident in the study as most of the farmers stated that they receive weather information from the television and radio, mostly in their local language IsiXhosa as it is easy to understand. However, these sources of weather information have been critiqued in their ability to disseminate weather information efficiently. Popoola *et al.* (2020) argue that television and radio disseminate general information and restrict interaction between the source of information and the end-user. Furthermore, Myeni & Moeletsi (2020) state that farmers with access to a television and radio do not have access to seasonal weather forecasts or rainfall distribution information throughout the season. Thus farmers find it difficult to make well-informed farming decisions. Therefore, as much as weather information is accessible, its accessibility also limits the efficiency of the weather information system in being used effectively and this can significantly influence the ability of farmers to cope with weather events.

IsiXhosa is the language farmers mostly receive weather information in, therefore the farmers mentioned that it is easy to understand and use. The large number of farmers understanding IsiXhosa is in line with what is the case in Maclear, where IsiXhosa is the dominant language. In this case, the kind of language used to communicate weather information increases the efficiency of the information communicated to the farmers, as it makes it easy for them to understand the message and better adopt/integrate the information in their farming activities. However, unlike the elderly farmers, all the young farmers (aged 18-35) and a couple of farmers aged between 35-60 mentioned receiving weather information from weather apps in English. English is not the local language of the farmers, and it can limit their understanding and reduce the efficiency of the information as farmers cannot fully use the language effectively as most of the farmers understand

IsiXhosa. Some farmers, especially those between the ages of 35-60 had a primary and secondary education. In relation to understanding weather information, 3% of the farmers stated that limited understanding of the information causes them to not use the information they receive. However, they did not get into detail. This can be linked to the language used as some of the terminology used especially if the information is communicated in English, may be difficult to understand for Xhosa speakers with a low education level. Language has been characterized as a serious barrier to knowledge transfer which can cause a gap in the information available or disseminated to people (Amano *et al.,* 2016). Language as a barrier has been closely related to low literacy levels, which acts as a limiting factor in people using weather information they receive as they have difficulties in understanding and interpreting the information (Ncoyini *et al.,* 2022). The issue of the language of communication needs to be looked at and considered when communicating weather information. The language gap needs to be bridged, and one of the ways to do this is having producers of weather information understand user needs so that information is simplified and communicated in the language its users understand. Additionally, Ncoyini *et al*. (2022) have suggested that scientists need to make an effort to be more accessible, equip and upskill farmers and extension officers. Benard *et al.* (2014) have also found that the kind of language used to communicate information can influence the understanding and use of weather information and can be a result of factors such as education level.

The education level could also influence the level of understanding, as most of the farmers have a primary and secondary education level. More males had matric and tertiary education compared to females, while most females had a primary and secondary education. This can be attributed to the gender differences in South Africa, which are typically due to socially constructed norms that reinforce patriarchal structures (Tibesigwa & Visser, 2016). According to Babugura *et al*. (2010) in South Africa, female farmers are seen as household caregivers. They do not have control over the use of their time and have limited resources than men, which may have an influence on their education level. This may mean they do not have the time to pursue their education further. On the other side, men are viewed as providers and are involved in more off-farm activities that yield more income (Tibesigwa & Visser, 2016). Therefore, men are likely to have the resources and the time to further their studies, which can give them more access to weather information and can also deepen their understanding.

Another important aspect of weather information efficiency relates to how frequently the information is communicated to farmers to allow them to make well-informed decisions on their farming activities and prevent losses. Most of the farmers expressed that they receive weather information daily, which is helpful in planning farming activities, especially knowing the best times to plant crops and vegetables. However, none of the farmers mentioned receiving weather information seasonally, this could probably be because farmers are not aware of seasonal forecasts and where to access them. Receiving weather information daily can limit farmers from planning for the upcoming season as they do not receive information on the upcoming season or month. Receiving weather information daily is not enough to effectively inform farmers decisions as farmers cannot prepare on time for a dry or wet season which may have devastating impacts on their farming activities. Therefore, smallholder farmers would indeed appreciate receiving seasonal forecasts. For example, if the farmers would know there would be good rainfall in the upcoming season, they would maximize on this information by planting crops that are suited for the rainy season and reduce costs by avoiding planting crops that do not thrive well in wet conditions. However, seasonal forecasts have several challenges. The formats used to communicate seasonal forecasts such as probabilities are not very useful for end-users, especially for smallholder farmers. Mogotsi *et al.* (2011) have found that presenting forecasts as probabilities is confusing for farmers with a low education level as they are difficult to understand. It would pose a challenge for smallholder farmers to understand and correctly apply the information in their farming practices and decision-making. Therefore, in the present study, as much as the farmers would appreciate seasonal forecasts, it would be challenging to understand the new information. Vincent *et al.* (2013) have suggested that seasonal forecasts need to include some element of interpretation which could be information on the impacts of the forecasted weather. Therefore, rather than probabilities only, guidance and advice on understanding and using seasonal forecasts should be provided, especially to smallholder farmers.

The use of indigenous knowledge, was another interesting way farmers used to predict weather conditions. In the present study, indigenous knowledge was reported to be vital in predicting weather conditions. For example, most of the farmers mentioned that they use indigenous knowledge indicators such as the presence of the barn swallow, dew in the grass, color of the clouds, and direction in which the moon is facing to predict weather conditions. An interesting indicator that the farmers use is the direction of the moon which indicates a range of weather conditions. The farmers expressed that the direction in which the moon is facing indicates that weather conditions will be windy, warm or rainy. The farmers praised the usefulness of the moon in their decision-making, as they expressed that allows them to make well-informed decisions on their farming practices such as knowing when to plant, harvest and what to plant. Therefore, it is important to note that the moon is an important indicator that can be very useful, especially for farmers dependent on rainfed agriculture. This study's finding is similar to the results presented in a study conducted by Basdew *et al.,* 2017, where farmers indicated using the direction in which the moon is facing to predict weather conditions. This result shows that weather predictions using the direction of the moon are still helpful even today. In Ethiopia, farmers interpret winds blowing in one direction close to the time of land preparation as a sign of drought (Mengistu, 2011). This finding may be applicable in the contexts of the farmers in this study, as they mentioned they are currently experiencing drought periods. The study findings show that indigenous knowledge needs to be recognized as an essential social and cultural tool for understanding and estimating weather conditions and informing farming decisions. Therefore, interpersonal sources such as neighbors are essential, as they allow the exchange of indigenous knowledge among farmers. Indigenous knowledge also allows farmers to be attentive to changes on long time scales and to compare present conditions to conditions in the past. Since farmers are able to draw knowledge from the past, this knowledge is of value. Indigenous knowledge needs to be considered an important source as it also enables farmers to learn from each other regarding knowledge, skills, and experiences. Furthermore, scientists can draw from farmers indigenous knowledge climate patterns for the identification of areas at drought risk (Orlove *et al.,*2010). This can be helpful in the context of farmers in the study, as they are currently experiencing drought periods. In the issue of the importance of indigenous knowledge as a source of weather information, Orlove *et* al. (2010) stress the potential of indigenous knowledge, such as the social nature of indigenous knowledge can help national meteorological services to develop new effective ways of communicating forecasts.

Interestingly, most of the farmers mentioned that they use the weather information they receive to make decisions that inform their farming practices. Most of the farmers mentioned that they use the weather information for planting and harvesting, while a few use it for land preparation and to know the best appropriate time to apply fertilizers and herbicides. These decisions can be possible land management strategies which can influence information uptake and use. Most of the farmers expressed issues of concerns with the information, they stated that the information is sometimes inaccurate, misleading, unreliable, and not trustworthy. They went on to say that it negatively affects their farming activities and decisions, as it causes them to experience losses they have not planned for. For example, the farmers recalled a recent instance that occurred in December 2021 where the weather forecast predicted that there won’t be rainfall in the local area of the farmers, but farmers expressed that they experienced heavy rainfall, which damaged their vegetables and crops that led to losses in terms of income and food. Weather information accuracy can affect the confidence of farmers in the information they receive and can speak to the long-term value of accepting weather information communicated where the information can be misleading in 2 out of 10 years but leading to a beneficial decision in 8 out of 10 years. Perceived accuracy of weather information can also be influential on whether the information can be used or not (Orlove *et al.,* 2010), and this can also limit farmers ability to take action, which may result in a missed opportunity to maximize benefits. This indicates that weather information that is inaccurate and misleading can affect the efficiency of the system. Blench (2003) argues that the dissemination of forecasts needs to be coupled with some form of support or training to ensure understanding. If this is not done, Blench (2003) states that it would be difficult to improve the trust and confidence of farmers in the forecasts as it could be continually dismissed because of their perceived inaccuracies.

In terms of the challenges farmers face with the information they receive, most of them raised the issue of scale. The farmers expressed that the weather information they receive is not downscaled to their local scale, as the closest information they can receive is of nearby towns such as Umtata, which is located 111.8 km away. The farmers also expressed that the weather information they receive can be misleading, which can lead to poor decision-making. According to Fitt (2014), weather information that does not cover the local scale of farmers can limit their ability to use the information effectively as the information is not what is needed by farmers at the local scale to make good decisions. A lack of coverage of the local scale is an issue of concern, and it reflects a significant gap between information disseminated to farmers and information needed by the farmers which can be applicable to their contexts. The reason for the limited availability of weather information that applies to the context of the farmers could be that there is a limitation of weather stations to accurately predict the weather conditions that apply to the context of the farmers. In Africa there is a limited availability of weather information, this is because it has been found that there is a lack of weather stations, especially in small towns and rural areas which is contributing to increased uncertainty and unreliability of weather information (van der Burgt *et al.,* 2018). A lack of weather stations limits the availability of weather information that applies to the context of the farmers, which can further limit them from making decisions that apply to their contexts. This is an issue of concern in the African continent, and something needs to be done urgently. As a way forward, Bohn (2003) suggests that there is a need to find a scale in which forecasts can achieve optimal benefits and meets farmers desires.

In the study, the characteristics of weather information, such as language, source and format of communication, allow farmers to understand and make good decisions on their farming practices. However, some of the characteristics limit the efficiency of weather information system as the needs of farmers are not fully covered. Weather information is not communicated or accessible in a manner the farmers would like. For example, the language of communication in sources such as weather apps and the internet is English which is not the language farmers can understand. The scale in which weather information covers is not downscaled to the local scale of farmers, and the frequency in which the information is communicated limits the ability of farmers to prepare on time for weather events that will happen in the upcoming month or season. As a result, these indicate a gap between weather information production, design, and user needs. This affects the efficiency of the current weather information system and calls for a need to improve the current system.

## 5.2 Improving the current system

In improving the current weather information system, the farmers suggested ways to make the system more efficient. All the farmers expressed their needs as a way of improving the current system of weather information. Starting with the type of weather information they need, the farmers mentioned that they need information mostly on drought, heavy rain, and rainfall. The farmers expressed a great need for information on drought because they are experiencing dry periods and want to prevent crop and income losses. Receiving information on drought can play a vital role in adaptation as this information can allow farmers to prepare on time for a drought event. They can prepare on time by implementing adaptation strategies such as harvesting rainwater. The farmers also expressed benefits that receiving information on drought can have on their farming practices. These are that the information can help them to plan on time and to know when to plant crops and vegetables to prevent crop and financial losses as crop farming is a major source of income. Stressing on the importance of weather information Kumar *et al.* (2020) found that drought and heavy rainfall information are important as this information can help in saving crops from drought and waterlogging conditions on time, which would positively benefit farmers in terms of food and income. This applies in the context of the farmers as they expressed concerns about drought and experiencing damage on their crops and vegetables because of heavy rainfall. In addition, heavy rainfall information can potentially lead farmers to plant crops that thrive well in wet conditions, thus resulting in high yields (Cooper *et al.,* 2008). This indicates that disseminating the appropriate information that applies to the context of farmers can help farmers plan on time and make decisions that can reduce losses and positively impact their livelihoods. Therefore, information on drought can serve as an improvement to the weather information system and its efficiency as this can allow farmers to make better decisions on their farming practices and planning based on the conditions they experience within their contexts. Making good decisions also relies on the timing of the information.

Interestingly, most of the farmers preferred to receive weather information daily, and they also indicated that they would like to receive the information weekly, monthly, and seasonally. This preference on other frequencies of communicating weather information shows that farmers want to move beyond receiving information daily as this can have more positive outcomes on their farming activities. This finding shows that they are interested in timescales where their actions can reduce the impacts of severe weather events. Therefore, this shows the need to improve the current system to communicate weather information beyond daily to alert farmers on weather conditions in the upcoming month or season to maximize benefits or minimize costs or effects. This finding also relates to the importance of seasonal forecasts in agriculture in helping to plan and prepare on time (Mkuhlani, 2021). In terms of the use of the information, farmers expressed that they want to be able to plan their farming activities on time, and to also know whether the upcoming season will be wet or dry, which is interesting as the farmers expressed in the early sections that they are experiencing dry periods.

To improve the sources, farmers can receive weather information to increase accessibility, use, and understanding. Most of the farmers expressed that they would prefer to receive weather information from the television and radio (Figure 8). This could be because farmers are only aware of these sources of information or that they only have access to these sources. In Maclear, more than half of the population (69.4%) has access to a television, and 45.3% have access to a radio (Stats Sa, 2021). Therefore, farmers prefer these sources the most because it is easier and more convenient for them to receive weather information (Ncoyini *et al.,* 2022). Interestingly, a few of the farmers who were young farmers preferred to receive weather information from the internet, and they expressed that this is because of easy accessibility and the convenience of being able to view weather information of an area of preference at any time of the day. Receiving weather information at any time of the day can improve farmers decisions in a way that it will allow them to be up to date with their decisions and to be fully aware of weather conditions. This can have a positive impact on planning and implementing strategies that may be beneficial to their farming practices. The low preference of the internet as a source of weather information could be because of limited internet access. In Maclear, 79.2% of the population has no access to the internet (Stats Sa, 2021). This could be because of a lack of awareness on the role of the internet in providing weather information. Limited access to the internet has also been linked to factors such as limited financial resources that affect weather information accessibility (Popoola *et al.,* 2020). Accessing the internet nowadays is not cheap because internet data is expensive and difficult to afford, especially in the face of high unemployment, which currently sits at 34.5%. To improve access on advanced sources of information, Selwyn *et al. (*2003) have suggested that sources of information such as the internet need to be promoted in rural areas, and farmers need to be empowered with the knowledge and skills to use and understand the information. The internet nowadays is becoming a prevalent tool for sourcing information, and has the ability to provide more options and opportunities to people to access informative information (Deshpande *et al.,* 2014).

Another important perspective to consider is the influence of age and education on the preference of receiving weather information from the internet. According to Wilson's Model of Information Behavior (Wilson, 2016), age, educational level, and income influence the kind of sources small-holder farmers receive information. This finding was evident in the study, as most of the farmers aged between 35-60 and 60 above preferred to receive weather information from the television and radio, while the young farmers preferred the internet. This result could be related to the education level and skills of the farmers. For example, the young farmers have a higher education level as they mentioned they have a matric and a tertiary education. This can play a positive role in allowing the farmers to understand the information. In correspondence, it has been found that educated individuals process information on advanced technologies such as the internet more quickly and effectively than uneducated individuals or with a low education level (Foster & Rosenzweig, 2010).

In terms of the language of communication, all the farmers mentioned that they would like to receive weather information in IsiXhosa. This finding could be because 86.4% of the population in Maclear speaks IsiXhosa (Stats Sa, 2011), which means most of the population can understand the language. As a result, efforts need to be made to communicate weather information in the language users of information understand as this will allow them to better use the information. Therefore, communication of weather information that farmers need, when farmers need it, how, and the language, can help the producers of weather information to understand the type of information farmers need and to know when to communicate the information. Which, in turn can have a positive impact on farmers understanding and use of the information.

## 5.3 The specific role of agricultural extension officers

From agricultural extension officers perceptions, farmers receive information on rainfall, temperature, and heavy rainfall. They mentioned that they receive this information from the television, neighbors, weather apps, and radio daily which is similar to what farmers expressed in their responses. Interestingly, none of the officers mentioned that farmers receive weather information from extension officers. This result was surprising as extension officers are expected to be major sources of information to farmers because of their bridging situation between national/provincial information and farmers. This finding is similar to the responses of the farmers where only one farmer mentioned receiving weather information from extension officers. This could be a different extension officer as the one's that were interviewed in the study as the farmer did not get into detail on who the extension officer is. The limited mentions of extension officers as a source of information shows the inefficiency of extension officers as a source of weather information. They are lacking the role of disseminating weather information. This could be related to some of the challenges the extension officers expressed when it comes to communicating weather information to the farmers. They mentioned that they receive inadequate training regarding weather information use and understanding. In South Africa, it has been found that most extension officers misinterpret basic forecast terms (Patt *et al.,* 2005), and fail to guide farmers on coping with extreme weather conditions. This is a concern as misinterpretation of weather information can potentially lead farmers to make poor decisions that may have detrimental outcomes. Further factors that affect their effectiveness in communicating weather information to the farmers, extension officers mentioned that they experience issues with logistics, such as not having transport to visit the farmers as they live far from the farmers. This result can be related to limited financial resources, which may play a role in limiting extension officers from accessing farmers when needed and can further affect the reliability of extension officers as a source of information. The above-mentioned call for the need to engage extension officers in training programs to improve their understanding and to equip them with effective ways to communicate weather information to farmers.

In the study, all the extension officers also expressed concerns about the information they wish to receive. They preferred to receive information on pests and diseases, and they explained that in 2021 farmers gardens were attacked by armyworms, which led to the loss of crops and vegetables therefore, they need information on pests and diseases, especially on armyworms to warn farmers on time as the area gets attacked by armyworms. This finding shows that farmers and extension officers have limited information on pests and diseases in rural areas. The officers related this limitation to a lack of information and accessibility. This shows a need to increase the accessibility of information that can be useful for extension officers and indirectly to farmers. Interestingly, in terms of the language, extension officers all preferred to receive information in English. This is different from the farmers responses, and this could be because extension officers have a higher education level than farmers and therefore can understand the language better.

Moreover, most of the officers preferred to receive weather information from Disaster. They expressed that the office provides them with detailed, reliable, and informative information. This source indicates differences in the sources of information in which farmers and extension officers receive weather information. This could be because farmers do not know where the Disaster office is or have no access to it. On the other hand, this finding can show that extension officers receive weather information from more advanced and reliable sources, which could be beneficial for the farmers in terms of their farming activities and decision-making.

Therefore, these findings suggest that there is a need for extension officers to get training to enhance their understanding and use of weather information. Extension officers have a great potential to effectively communicate weather information to smallholder farmers as they are much more aware of their challenges and live in close proximity to them, which would make it easier to build relationships (Ncoyini *et al.,* 2022). In addition, training is a vital component to ensure proper delivery of weather information from extension officers to farmers. In the study, farmers and agricultural extension officers strongly voiced the need for training to improve the communication and use of weather information. The farmers mentioned that with training, they would also like to know how they could improve their farming activities with the information they receive. Increasing access to other sources of information was also expressed by the farmers. Some of the elderly farmers mentioned not having access to the television or neither smartphones. Therefore, they expressed the need for extension services to help them better access weather information. Therefore, training among extension officers needs to be prioritized.

# Chapter 6: Conclusion

The primary aim of this study was to identify the weather information needs of smallholder farmers in the Eastern Cape province of South Africa. For this aim to be achieved, several objectives were put forward to investigate the needs of the farmers. This research has shown that weather information that smallholder farmers receive is helpful in their farming activities as it helps to inform their decisions and farming practices. Most of the farmers receive rainfall and temperature information and this information helps them to know when to plant, harvest, and to apply herbicides/pesticides. Farmers mostly receive weather information from the television and radio, and this information is mostly communicated in the local language of farmers which IsiXhosa. According to the farmers IsiXhosa is easy to understand. Farmers receive weather information daily, this frequency helps farmers to plan their farming practices, but it is not effective in fully informing farmers decisions. This is because farmers do not receive information on the upcoming season and this can negatively affect farmers activities.

As much as farmers receive weather information, this does not mean the weather information system is efficient. Farmers expressed their needs, to help improve the current weather information system. Improvement of the current weather information system is a process and it is important to note that progress is being made to reduce the impacts of weather and climate events on farmers. Most of the farmers expressed that they need information on drought to know when to plant crops and vegetables and what to plant. The farmers further mentioned that they are currently experiencing dry periods. Therefore, the information on drought would help to prevent crop and financial losses. Most of the farmers preferred to receive weather information from the television and radio, while a few preferred the internet, with none preferring weather apps, SAWS, or extension officers. When the farmers mention that they receive information form the radio and television, the forecast is provided by SAWS. This finding shows that farmers only receive information from these sources and that they may be unaware of the other sources of information or have limited resources to access information from these sources. As a result, this shows a need to increase the diversity of sources in which farmers can receive weather information, but most importantly increase accessibility to more advanced sources. A starting point can be raising awareness on various sources of weather information so that farmers can be aware of them and also empower farmers with knowledge and skills to use the sources. The frequency of communicating weather information is limited to daily, and the farmers expressed that they would like to receive the information daily, weekly, monthly, and seasonally. This shows that as much as receiving weather information daily is good, it is not enough to allow farmers make well-informed decisions on their farming activities as it is not efficient in planning for an upcoming season that will be dry or wet. Therefore, this brings a need to communicate weather information as efficiently as possible so that farmers are aware of how weather conditions will be daily, and how the upcoming month or season will be.

There are a number of challenges in the weather information system that affect the use and understanding of weather information. Most of the farmers expressed that the weather information they receive can sometimes be misleading and does not cover their local scale, which limits the application of the information in their local context. The farmers also expressed issues of a lack of understanding of the information as a result of the language and terminology used to communicate the information. These challenges limit the ability of farmers from effectively using the information in their contexts, and these can affect the adaptation capacity of farmers from weather events. Therefore, addressing these challenges is critical to reduce the vulnerability of farmers from the impacts of weather events and to improve the use and understanding of weather information. Not all challenges can be addressed all at once, but prioritizing is critical. Downscaling of weather information to cover the local scale of farmers, incorporating the needs of farmers, and training farmers to better understand and use weather information are critical and need to be addressed.

Overall, understanding the needs of smallholder farmers in this study can improve the design and communication of weather information by allowing producers of information to understand the needs of farmers. This research is also essential, especially for smallholder farmers, who are the most vulnerable to extreme events. It will raise awareness on the needs of farmers, which can help in playing a role in having these needs taken into account when weather information is communicated. It can help farmers receive appropriate weather information and can positively reduce the impacts of extreme events. Therefore, the outcomes of this study are not only important in ensuring that the information is tailored to meet farmers needs, but also to improve the use and understanding of the information to enable farmers to adapt and cope to extreme weather and climate events.

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# Annexes

## Annex 1: Interview questions for farmers

**Baseline and characteristics of weather information smallholder farmers receive and use.**

1a. Do you currently receive weather information? If so, what kind of information?

1b. If not, please elaborate.

2a. Did you receive weather information before?

2b. If not, why did you not receive weather information?

2c. If you did, where did you receive weather information?

2d. Currently where do you receive weather information and what kind of information do you receive?

3. In which format is the weather information you receive communicated to you? Do you understand the information in this format and why?

4. How frequently do you receive weather information?

5. Do you receive weather information as frequently as you would like to? If yes, why do you say so?

6. In which language do you receive weather information, do you understand the information in this language and why do you say so?

7. Do you use the weather information that you receive? What do you use the information for i.e what decisions do you make with the information?

8. If you receive and do not use weather information, please state why.

9. How can weather information use and understanding be improved?

**Weather information needs of farmers**

1. What kind of weather information do you need? please state why.

2. In which source would you prefer to receive weather information, and why?

3a. In which format do you prefer to receive weather information? Please explain why this is your preferred format.

3b. Do you understand the format of the information; why do you say so?

4. How frequently would you like to receive weather information, and why would it be important to receive it at this time.

5. In which language would you prefer to receive weather information, please explain why?

6. Overall, do you think weather information can help you in making better decisions? Please justify your answer.

**Demographic profile**

7. Demographic information

1. Farming experience/number of years as a farmer?
2. In which location/village is your farm located?
3. Household size
4. Household head
5. Employment status
6. What do you identify as: male/female/other
7. Age group that you fit in? 18-35, 35-60, <60
8. Level of education: no education/primary/secondary/matric/tertiary
9. Source of income: crop/livestock farming/off-farm activities

## Annex 2: Interview questions for agricultural extension officers

**Baseline and characteristics of weather information smallholder farmers and extension officers receive and use.**

1. What kind of weather information are smallholder farmers and extension officers receiving? What kind of decisions do they make with the information?

2a. Where do smallholder farmers receive weather information?

2b. Where do extension officers receive weather information?

3. In which format are farmers and extension officers receive weather information?

4. How frequently do farmers and extension officers receive weather information?

5. In which language do farmers and extension officers receive weather information?

**<u>Weather information needs of smallholder farmers and extension officers</u>**

1.What kind of weather information do smallholder farmers and extension officers need? What decisions would they make with the information?

2. In your own opinion, which source do you think farmers and extension officers would prefer to receive weather information?

3.Which format do you think would be suitable for farmers and extension officers to easily understand weather information? Please state why.

4.How frequently do you think farmers and extension officers would prefer to receive weather information? Why?

5. In which language do you think farmers and extension officers would prefer to receive weather information? Please explain why.

6. Overall, do you think weather information can help in making better decisions? Please justify your answer.

7. In your opinion, how can weather information use and understanding be improved?