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RESEARCH REPORT

Title: **Seasonal Forecasts: The Experiences of Eastern Cape and Western Cape Farmers**

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Supervisor: Prof. Andrew Thatcher

A research project submitted in partial fulfilment of the requirements for the degree of Masters by coursework and research report in the field of Industrial and Organisational Psychology in the faculty of Humanities, University of the Witwatersrand, Johannesburg, South Africa.

15 March 2023

PLAGIARISM DECLARATION

Masters in industrial and Organisational Psychology – Research Report

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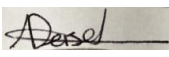
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ACKNOWLEDGEMENTS

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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Table of Acronyms

ATU: Attitude towards use	24
EC: Eastern Cape	16
IBT: Institution-based trust	26
PEOU: Perceived ease of use	24
PU: Perceived usefulness	24
SAB: Structural assurance beliefs	26
SFs: Seasonal Forecast	3
SNB: Situation normality beliefs	26
SST: Sea-surface temperature	23
TA: Thematic Analysis	32
TAM: Techonolgy Acceptance Model	24
United Nations Framework Convention on Climate Change	18
WC: Western Cape	3

Chapter 1

1.1 Introduction

Climate scientists around the world have stressed the adverse impacts of climate change. Consequences of climate change could lead to catastrophic global events such as droughts, wildfires, inland flooding, and heat waves. Furthermore, this could lead to global water and food shortages as well as the displacement of millions of individuals as entire regions of the world may become uninhabitable (Arnell & Gosling, 2016). The world as we know it will dramatically change.

The impacts of global warming have led to alarming changes in global temperatures, a rise in sea levels and other damage to the environment caused by human activity and climate change induced natural disasters (Theron et al., 2021). Drastic shifts in weather patterns adversely affect different sectors of the economy in various countries. Climate change has resulted in larger climate variability within South Africa which negatively affects the agricultural sector. Shifting weather patterns have resulted in the destruction of agricultural crops (e.g., from hailstorms or drought) and have further reduced crop yields (Talanow et al., 2021). This has negative economic consequences and often results in job loss, loss of income, and the reduction of agricultural exports (Berrang-Ford et al., 2011). As it stands, South African farmers have yet to build their resilience to climate change. However, this may be partly achieved through the implementation of seasonal forecasts (SFs). Such information is highly relevant to weather sensitive sectors and can often influence the decision making of actors. This is particularly useful as information regarding seasonal temperatures and the average rainfall patterns for the growing season may influence farmers' decisions ahead of time regarding which crops should be planted and when they should be planted. While the benefits of SFs are abundant, they are often not adopted by agricultural experts (Golding et al., 2017). This is because farmers often face difficulty interpreting the predictions due to a lack of understandability. Furthermore, there are various challenges associated with inaccessibility, the availability and adoption of new technologies, as well as the motivation to implement them. It is, therefore, imperative that we enhance the usability and understandability of SFs as a way of ensuring their adoption in agricultural practices. The study aims to enhance the resilience of farmers through the adoption of SFs. This may be achieved by examining farmers perceptions regarding the ease of use, usefulness and trustworthiness of the SF.

Chapter 2

Literature Review

2.1 Crop farming

Crops, according to Erasmus et al. (2000), refer to the production of field harvests, fruits, or vegetables. Within South Africa field crops are divided into summer crops which consist of soybeans, maize, sunflower seeds, and groundnuts (amongst others) while winter crops are mostly cereal grains such as wheat, canola, and barley (Mathinya et al., 2022). Field crops account for the largest area of cultivated land in the country. The majority of crop plants from 2007-2017 were maize, wheat, beans, soya, sugarcane, and sunflower seeds (Tongwane et al., 2016). In 2017, field crops generated 23% of the total farming income which amounted to approximately R69 billion (Department of Statistic South Africa, 2017). South Africa has a total land area of 127 million hectares of which 46.4 million is used as agricultural land (Thamaga-Chitja & Morojele, 2014). However, only 14% of agricultural land receives adequate rainfall for the arable production of crops (Department of Statistic South Africa, 2017).

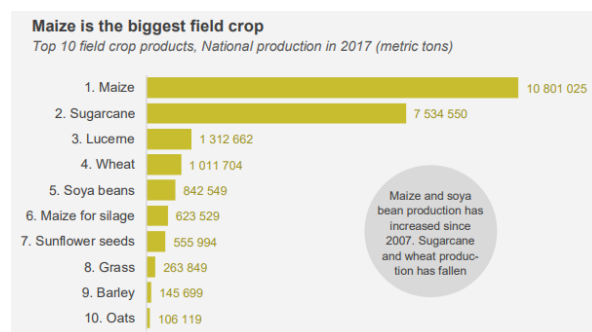


Figure 1 Crop Production in South Africa (Statistics South Africa, 2017)

The onset of the twenty-first century has dramatically altered the agricultural sector. Worldwide food productivity soared due to specialisation, mechanisation, and policy development (Srinivasan, 2006). However, this was coupled with increasing production costs, ground water contamination, topsoil depletion, and the decline of family-owned farms (Jacobs et al., 2018).

South Africa is commonly considered as a food secure nation. However, climate change has increased the uncertainties and risks associated with rainfed farming. Reports from the World Food Programme indicate that crop yields per hectare is currently increasing at a rate below the global population average (Masipa, 2017). This indicates that the production of food will

not meet global demands in the immediate future, resulting in millions of individuals becoming food insecure (Masipa, 2017). The rapid increase in population growth necessitates an increase of 60% in food production in order to ensure food security by 2050 (Jacobs et al., 2018). In South Africa, the production of crops is under pressure due to high input costs, climate change and the associated unreliable rainfall, as well as biased competition in the highly subsidized international market (Srinivasan, 2006). Farmers need to enhance their agricultural output and make use of available resources through precision agriculture in order to reduce growing levels of food insecurity.

The agricultural sector within South Africa is dualistic, as it consists of a developed commercial sector and a lesser developed small-hold sector located in former homeland areas (May & Meth, 2007). Within South Africa, the commercial farming sector accounts for approximately 95% of marketed agricultural outputs while smallholder farming accounts for 5% of the outputs. There are approximately 50 000 to 60 000 commercial farmers within the country who play a dominant role in the production of food for the nation, with the vast majority of farmers identifying as White (Hall et al., 2017). Contrary to this, small-hold farmers constitute a much larger number of individuals from the rural population of the country (May & Meth, 2007). Oettle et al. (1998) reported that 1.2 million small-hold Black farmers share approximately 17 million hectares of land while 60 000 white commercial farmers occupy 102 million hectares.

There is a stark difference in the pre-conditions and lifestyles of small-scale farmers and commercial farmers. Large-scale commercial farmers are defined as producers that dominate the system and operate within multinational corporations across the country and internationally. In contrast, small-scale farmers exist at a subsistence level and occasionally sell surpluses on local markets (Hall et al., 2017). While commercial farmers have thousands of hectares of land, small-scale farmers practice subsistence farming on land plots generally less than one hectare (Hall, 2004). As different as they are, both groups are exposed to similar climate conditions, however, their levels of adaptive capacity and vulnerability indicate how well each of them are able to recover from climate adversities (Thamaga-Chitja & Morojele, (2014). Commercial farmers generally aim to maximise their crop yields in order to enhance their profits from market sales. Conversely, small-scale farmers consider variety as they consume their own production and sell any surplus to neighbours or local markets (Wilk et al., 2013). Enhancing the adaptive capacity of both groups is integral in that it reduces the

challenges they face in relation to the current climate variability and market-related risks (largely commercial) or food security (largely small-hold).

2.2 The Eastern Cape

The Eastern Cape (EC) accounts for 9.7% of the country's agricultural output and is the second largest province (Mujuru et al., 2022). Furthermore, it accounts for 37.1% (third largest in the country) of the country's commercial agricultural land (Khapayi & Celliers, 2016). The province hosts a large percentage of the country's livestock and is the largest producer of mohair and wool. In relation to crop farming, the province cultivates a large variety of crops such as maize, dry beans, sugar beet, flax, hemp, lucerne, and chicory (Mujuru et al., 2022). The EC also produces various fruit and vegetable crops such as lemons, pineapples, guavas, apricots, oranges, potatoes, spinach, onions, tomatoes, cabbage, pumpkins and carrots (Department of Statistics South Africa, 2017). The agricultural sector within the EC consists largely of small-scale subsistence farmers.

No standard definition has been provided for the term small-hold farmer within the South African context, however, the concept is generally used to describe individuals that are distinct from large-scale commercial farmers and otherwise identify as Black (Rockström et al., 2002). It is worthy to note that there are no distinctions between communal, subsistence, small-scale or emergent farmers. This study however defines small-hold farmers as Black individuals that reside in former homelands (Mupangwa et al. 2011). Within South Africa, small-scale farmers often have difficulty acquiring land, lack skills and resources, often do not have formal education in agriculture, and are therefore unable to adapt to rapidly shifting climate conditions. Furthermore, Muzangwa et al. (2017) notes that subsistence farmers do not have access to the investment capital needed for expensive adaptation strategies. This further heightens their vulnerability to environmental threats caused by climate variability.

Small-hold farmers production is commonly under optimal levels and results in low levels of productivity (Rockström et al., 2002). This is closely linked to natural, socio-economic, and financial factors (Rockström et al., 2002). Agronomic constraints such as planting dates, water (rainfall), nutrient management, and tillage practices all contribute to the challenges faced by these farmers (Mupangwa et al. 2011). Within South Africa, rainfed crops are concentrated in the eastern and central parts of semi-arid regions as well as in sub-humid zones. Unlike commercial farmers that utilize irrigation, dryland farmers battle droughts without irrigation. Therefore, knowledge regarding the incidence of drought is crucial as it enables farmers to prepare using the necessary measures in order to prevent crop failures (Mupangwa et al. 2011).

In addition to drought, timely weed control, the hydrological properties of the soil, and cropping timeframes need to coincide with rain.

Small-hold farmers in the EC grow crops on two classes of land; homestead gardens and fields (Mnukwa et al., 2022). One of the main purposes of such farming is to grow maize for their own consumption. The intercropping of maize in their fields is becoming increasingly common (Metula & Osunkunle, 2022). Only a small number of farmers continue to practice maize monoculture, while the majority of farmers utilize a three-crop mixture consisting of maize (the major crop), cucurbits (gourd vegetables such as pumpkins and squashes) and beans as minor crops (Mdoda et al., 2022).

Small-hold farming plays a crucial role in the country regarding food security, income generation, and the creation of employment (Moswetsi et al., 2017). Approximately 1.3 million rural households in South Africa rely on dryland agriculture with the majority located in Limpopo and the EC (Hall et al., 2017). Over 30% of rural households in the EC depend on agriculture and subsistence farming. In order to ensure sustainability and viability, the country has tried to incorporate small-hold farming into various development and support programs. This was aimed at enhancing sustainable use of natural resources, enhancing productivity, and facilitating economic growth within rural communities across the country (Moswetsi et al., 2017). Alleviating food insecurity within such regions remains a challenge due to high levels of poverty and unemployment. While irrigated agriculture has been cited as an appropriate way of addressing such issues in other countries, water deficits within the region renders this ineffective (Moswetsi et al., 2017).

Water management is a particularly challenging issue for small-hold farmers. South Africa has an average annual rainfall of approximately 450mm with more than 80% of the country's land classified as semi-arid (Fanadzo et al., 2010). Without irrigation, dryland farmers are much more sensitive to- and likely affected for much longer periods by drought conditions in large parts due to constraints regarding financial resources (Mupangwa et al., 2011).

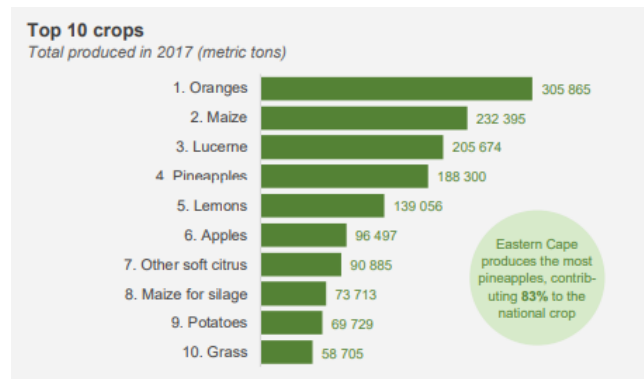


Figure 2 Eastern Cape Crop Yields (Statistics South Africa, 2017)

2.3 The Western Cape

The Swartland and Overberg regions are municipalities in the Western Cape (WC) province of South Africa known for the production of cereal crops. The WC accounts for 20% of the national total agricultural output and 12% of the country's total agricultural area (Talanow et al., 2021). The region has a Mediterranean-type winter rainfall with an Atlantic Ocean influence, rendering it particularly favourable for cereal farming such as wheat, barley, oats and viticulture (Western Cape Government, 2015). The production of grain crops covers 60% of the cropland in the region, with wheat as the main grain under cultivation (Western Cape Agristats Dataset, 2018). Within South Africa, winter cereals are produced in the winter rainfall areas. While wheat is produced throughout the entire country, the WC contributes almost half of the overall production and forms part of the winter rainfall region (Mathinya et al., 2022).

Within the WC, the production of grain is highly sensitive to temperature increases (heat waves), longer dry spells, reduced rainfall and higher frequencies of concentrated rainfall (Araujo et al., 2016; Findlater, 2017). Winter rainfall (June to August) is greatly important to this region due to their large production of rainfed wheat during the winter season and high value of export crops (Talanow et al., 2021; Theron et al., 2021). Within the WC, the climate risks associated with the production of wheat include rainfall variability, inadequate or late start of the rainfall season (in April to June), rainy and warm conditions during harvest season, droughts, strong winds, and heat waves (Theron et al., 2021). Such drastic alterations in climate variability during planting and harvesting season results in major crop loss and sometimes even the inability to plant. The afore-mentioned shifts in weather patterns are some of the various impacts that climate change has.

Various farmers within the WC have adopted conservation agricultural techniques such as increasing permanent soil cover, introducing crop rotation, and practicing minimum tillage

(Talanow et al., 2021). However, they have yet to adopt effective mechanisms that enhance their resilience against climate change. Within the agricultural sector there is an assumption that crop prices and yields vary according to climate conditions due to the supply and demand within international and local markets (Archer et al., 2009). Farmers therefore are aware of the fact that not every year will be profitable, however, climate variability is increasing the number of non-profitable years (Archer et al., 2009). While the WC province has some of the wealthiest farmers, they are at a high risk of not being able to produce sustainable crop yields due to climate change. The province is currently under pressure to enhance their crop yields in order to reduce the chances of food insecurity within the country (Findlater et al., 2019). As a result, shifting climate conditions enhances the stakes of commercial farmers.

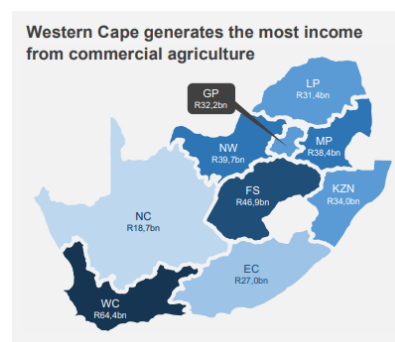


Figure 3 *Agricultural Production in the Western Cape (Statistics South Africa, 2017)*

2.4 Climate Change

The definition of climate change provided by Field and Barros (2014) is “a change in the state of the climate that can be identified (i.e., using statistical tests) by changes in the mean and/or the variability of its properties, and that persist for an extended period, typically decades or longer” (p.5). The United Nations Framework Convention on Climate Change (UNFCCC) further defines climate change as the “change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (Field & Barros, 2014, p. 5).

Climate change is one of the largest defining issues of the 21st century and refers to the shifts in weather patterns and temperature due to the impacts of human activity such as the burning of fossil fuels (Berrang-Ford et al., 2011). Greenhouse gases are generated through the burning of fossil fuels, they surround the Earth and trap heat from the sun and ultimately raising global temperatures (Change, 2007). The range of impacts due to climate change include shifting weather sequences, rising sea levels, melting of the polar caps, and many other natural

disasters. While climate has always changed naturally, human activities have undeniably riven the faster and larger than ever climate change we experience .

The climate crisis affects innate sources of human livelihood like the environment and by extension agriculture, disturbances in either of the two has catastrophic impacts on the survival of communities (Zwane, 2019). Globally, climate change is expected to transform agricultural productivity, increase food prices, and reduce food security due to a decrease in food production. The agricultural sector is inherently vulnerable to climate change as the sector is dependent on environmental stability and climate variables such as humidity, temperature and precipitation (IPCC, 2011). As a result, shifting weather patterns directly affect agricultural production (Maponya & Mpandeli, 2012).

The African continent as a whole is particularly vulnerable to climate change due to its low adaptive capacity and high exposure (Hulme et al., 2001). Over the last 100 years, surface temperatures on the African continent have increased by 0.5°C and projections highlight that those temperatures will rise faster than the global average (James & Washington, 2013; Sanderson et al., 2011). When examining the South African context, the agricultural sector is a vital source of livelihood for rural communities. It accounts for 10% of overall employment of the population and constitutes approximately 2.5% of South Africa's GDP (Gbetibouo, 2009). A decrease in crop production and harvesting may severely cripple the economy (Gbetibouo, 2009).

As it stands South Africa's population is already subjected to food deprivation, poverty, and high levels of inequality (Gbetibouo, 2009). The impacts of climate variability pose a critical challenge for the national development of the country due to threats on food security, water resources, infrastructure, as well as biodiversity and ecosystem-services (Ziervogel et al., 2014). It is therefore inherently important that the South African agricultural sector is able to enhance their adaptive capabilities in order to mitigate the impacts of climate change on the agricultural sector.

Evidence suggests that the average temperature in South Africa has increased over the last four decades (Benhin, 2008). Climate data was analysed from 26 weather stations across the country with 23 stations indicating an annual temperature increase (Benhin, 2008). The general analysis highlighted that on average the country's temperature increased annually by 0.13°C between 1960 and 2003. This varied across the seasons with an increase of 0.08°C in spring (September – November), 0.21°C in autumn (March – May), 0.12°C in summer (December – February),

and 0.13°C in winter (June – August) (Benhin, 2008). Furthermore, South Africa receives an average rainfall of 450mm annually. This is significantly below the global annual average of 860mm (NDA, 2001). It is important to note that rainfall is also unevenly distributed across the country as will be examined below. This poses various challenges, as more than half the water resources within the country are used for agriculture (NDA, 2001). Climate change has resulted in reduced rainfall and higher temperatures. Coupled with scarce water resources this has adverse impacts on both commercial and subsistence farmers.

2.5 Climate and Seasonal Changes

Seasonal variations are directly linked to climate change due to increased global temperatures (Hulme et al., 2001). Seasonality refers to cyclical processes or events that are correlated with seasonal changes such as the blooming of flowers in spring, rising temperatures symbolising the end of winter, and leaf-fall in autumn (Roufou et al., 2021). Seasonality is impacted by climate change in three different ways. Firstly, climate change alters the timing of when seasonal events occur during the year. As an example, shorter winters result in less winter rainfall coupled with drier and warmer conditions. This shifts water availability during the crop growing season which reduces crop yields or results in crops requiring more ground water usage (EPA, 2021). Secondly, the duration of seasonal events altered. Warmer winters result in crops growing earlier; the earlier onset of spring does not allow sufficient time for seeds to mature, and they are often threatened by drying when they should still be growing (EPA, 2021). Lastly, climate change alters the seasonal variability which changes the frequency and intensity of seasonal events such as the increased intensity of heat waves or rainstorms in summer (EPA, 2021). Changes in seasonality highlight tangible evidence regarding the impacts of climate change over relatively short time frames.

When examining this in the context of the WC, winter austral rainfall (June through August) is vital to the region. However, the rainfall season within the region is shifting as a consequence of climate change (Archer et al., 2019). This poses a challenge as the timing of winter rainfall is essential for wheat crops which are typically planted in May. Therefore, the desired rainfall timeframe is before the end of May, however, it is crucial that rain falls before mid-June (Archer et al., 2019). Furthermore, rain should also fall during the vegetative growth part of the season (June to August) and again in September during the reproductive phase (Archer et al., 2019). The EC region has an annual mean rainfall of 550-700 mm and consists of arid and semi-arid climate regions (Ndhleve et al., 2017). Desired rainfall within the region should be between October and March with incidents of snow between May and July (Archer et al.,

2022). The planting season generally begins around mid-October to December (but can sometimes continue until February), therefore rainfall is critical during this period (Archer et al., 2022). Disruptions in the afore-mentioned timing of rainfall in both regions is associated with potentially catastrophic effects on crop yields.

2.6 Adapting to Climate Change

The production of crops is directly influenced by changes in atmospheric temperatures, water supply, soil fertility, and precipitation (Benhin, 2006). Additionally, soil moisture and temperature control the crop development, while water requirements further determine the length of growing season (Calzadilla et al., 2014). Within South Africa, water availability is deemed the most limiting factor in agricultural production and, this is particularly important as patterns of rainfall are unevenly dispersed across the country (Zwane, 2019).

Adaptation is defined as the changes that arise within a defined system as a response to certain forces (Smithers & Smith, 1997). Within the context of climate change, it may be defined as the adjustment within a particular human system as a response to definite or unforeseen climatic stimuli, which exploits beneficial prospects or moderate harms (IPCC, 2007). The ultimate objective of adaptation is to prepare a response to the impacts of climate change and seasonal variations. Methods of adaptation vary across scale, place and activity (Pittock, 2009). Therefore, there is a need to be context specific and localised. Furthermore, adaptation may be facilitated through educating individuals regarding the benefits of adaptation and by raising awareness (Pittock, 2009).

Adaptation may encompass altering harvesting and sowing dates, planting several crops, crop diversification, hybrid crops, and implementing water conservation techniques (Abid et al., 2016; Roudier et al., 2016). At the farm level, adaptation measures include farm-level-decision-making in relation to the production, land topography, the use of land, and irrigation (Abbasi & Nawaz, 2020). Such activities highlight conserving nutrients and soil moisture, strengthening irrigation systems, changes in planting time and use of land, and crop variations (Abbasi & Nawaz 2020). Furthermore, individual level education and training of farmers, agricultural consultation services, altering fertilizer programs, and seasonal forecasting information may aid farmers in enhancing their adaptive capabilities (Abid et al., 2016). All of the aforementioned adaptive strategies may aid farmers in developing their resilience to climate variation.

2.7 Climate and Weather

The terms climate and weather are often used interchangeably. The difference between climate and weather is a measure of time. Weather may be defined as the shifting atmospheric conditions over a relatively short time span (Rummukainen, 2012). Climate displays the behaviour of the atmosphere over a longer period of time and further provides descriptions of long-term weather patterns within a particular area (Rummukainen, 2012). Essentially, the difference between weather and climate is that weather highlights the short-term changes in the atmosphere (minutes to months), while climate highlights the average of weather over years and decades (Ohba & Sugimoto, 2019). Ohba and Sugimoto (2019) explain climate as the statistical summary of weather events that occur within a given season and region usually measured over 30 years.

In addition to long-term climate change, there are shorter periods of climate variations. Climate variability highlights variations in climate that last longer than weather events but occur over smaller timeframes when compared to climate change (Rummukainen, 2012). Such variations in South Africa are attributed to intermittent or periodic shifts related to La Niña (cooler sea temperatures), El Niño (warmer sea temperatures) and other changes in the Earth's systems. This will be explained in more detail below.

2.8 Seasonal Forecast

The benefits of climate monitoring within agriculture have been recognised for centuries. The third president of the United States of America, Thomas Jefferson, was known to plan his farming operations around the climate conditions of the area (Hale, 1991). Long range forecasts date back to 1793, where the first Farmer's Almanac, an annual magazine paper, contained descriptions of climate conditions for the upcoming calendar year (Hale, 1991). Forecasts within the Farmer's Almanac were based on proxy data such as moon phases and the width of onion skins as well as recurring weather patterns (Hale, 1991). It is worthy to note that during that particular period, Native Americans were known for their long-term forecasts (Peppler, 2010). Tribes often based their knowledge on natural phenomena such as the amount of spider webs in the air and the thickness of corn shuck (Peppler, 2010).

Seasonal Forecasts (SF) aim to provide imperative information regarding the weather characteristics of the next weeks to months that are likely to arise in the upcoming season (Palmer et al., 2008). Due to the sporadic nature of atmospheric circulation, it is not possible

to predict daily weather patterns months in advance, therefore SFs provide estimations of future seasonal conditions over a specified period of time (Weisheimer & Palmer, 2014). Outputs of seasonal forecasting might highlight whether the weather in the coming season may be wetter or drier (or hotter or cooler) when compared to mean variations within a specific region. Seasonal Forecasts are usually produced on a three-month forecast basis and provide a probabilistic indication regarding the development of average conditions that may develop in the future (Weisheimer & Palmer, 2014). Unlike conventional weather forecasts, SF predictions do not entail the detailed (day-to-day) progression of weather patterns (Weisheimer & Palmer, 2014). Rather they aim to provide estimates of seasonal-mean statistics approximately three months ahead of the season (Palmer et al., 2008).

SFs inform on how likely it is that the up-coming season will be drier, wetter, colder, or warmer than normal (Weisheimer & Palmer, 2014). Such estimates are created using predictable seasonal-timescale signals that arise from the ocean, and at times from land surfaces, on the atmosphere (Orlov et al., 2020). A key construct in predicting seasonal forecasts is El Niño, an ocean-atmosphere phenomenon that occurs primarily in the Pacific that is predictable six months prior (Weisheimer & Palmer, 2014).

Seasonal Forecasts are driven by sea-surface temperature (SST) distributions. These estimates are used to determine if certain weather systems are likely to occur in comparison to the average events that have been historically recorded (Hansen et al., 2011). SSTs are a result of the atmosphere receiving moisture since the sea is heated through the Earth's surface (Hansen et al., 2011). As a result, significant shifts in the usual conditions of the Earth's surface may result in prolonged impacts on future weather patterns. They incorporate information regarding the considerations of SSTs (including the El Niño Southern Oscillation) as well as other factors within a broader scale of oceanographic and atmospheric drivers of seasonal variability (Soares et al., 2018). Additionally, oceanic temperatures provide methods of prediction regarding how future weather patterns may change (Hansen et al., 2011).

Golding et al. (2017) notes that climate forecasters and scientists need to support agricultural decision makers through the appropriate access to climate services. It is therefore inherently important that climate scientists develop suitable climate information that meets the requirements of farmers and agricultural experts. This study aims to enhance climate scientists' and seasonal forecasters' understanding of farmers' experiences using behavioural concepts and psychological theories, so that they are able to improve and redesign the current SFs. This

is intended to enhance the promotion and adoption of SFs by experts (i.e., farmers) in the field. This analysis aims to assist in the process of refining and remodelling SFs using information regarding how participants' perceived forecasting information. This will support climate scientists in enhancing the development of current SF models. Previous research conducted in the field by Muita et al. (2021) and Wilk et al (2017) highlight that there needs to be an improvement in the understandability and usability of existing SFs.

There has been growing awareness regarding the importance of the adoption of innovative agricultural technologies within the global South and developing nations. Developing nations are highly reliant on agricultural production to enhance their socioeconomic conditions, this highlights the importance of the implementation and adoption of innovative technologies in order to enhance production (Feder et al., 1985). The adoption of such technologies (SFs), however, has been met with constraints and partial success. It is therefore important that we understand the processes and influences involved with adoption as this may guide farmers towards adopting innovative technologies within their farming processes.

2.9 Technology Acceptance Model

The acceptance of new technologies has become a frequent area of inquiry in recent decades. The model most widely used is the Technology Acceptance Model (TAM) developed by Davis (1989) and examines the impacts of new technologies on human behaviour (Marangunić & Granić, 2015). TAM has its roots in cognitive psychology and was adapted from the psychological theory of reasoned action that explains the behaviours associated with accepting information systems (Ibrahim et al., 2017). The model was initially developed to measure the determining factors of computer usage but has been applied to explain the adoption of various other innovations. Moon and Kin (2001) used TAM to examine users' acceptance of the World-Wide-Web while Serenko et al. (2007) used the model to evaluate individuals' acceptance of interface agents in organisational applications. Furthermore, TAM has been used beyond the boundaries of the traditional workplace to determine intrinsic motivators of acceptance within the medical field (use of clinical information systems), the education sector (school counsellors' adoption of Naviance, an online learning tool) and the agricultural sector (the adoption of virtual reality applications designed for farmers) (Castiblanco Jimenez et al., 2021; Deslonde et al., 2018; Melas et al., 2011). Empirical research conducted by numerous sources has indicated that TAM is a robust and parsimonious model that explains the behaviours surrounding technological acceptance in various different settings (Silva, 2015). While the theory has been used considerably in the context of information technology acceptance and

other related disciplines, it is also applicable and has had considerable success in other non-organisational settings (Marangunić & Granić, 2015).

Davis (1989) asserted that the intention of using information technology drives its actual use. According to TAM the voluntary acceptance and intention to use a new technology is determined by two factors: perceived ease of use (PEOU), perceived usefulness (PU) of the new technology, and attitude towards use (ATU) (Lee et al., 2003). The aforementioned factors explain a user's intention to use the technology. Such factors impact the individual's attitude regarding their use of the technology which in turn affects their behavioural intentions, ultimately affecting the actual use (Lee et al., 2003). PEOU is defined as the extent to which an individual's belief regarding the utilization of a particular technology would ultimately be free of difficulty (Rafique et al., 2020). PEOU indicates the cognitive effort that the individual needs to learn in order to utilize the new technology. This may be understood as the understandability of the new technology (Rafique et al., 2020). PU is defined as the extent to which an individual believes that utilizing a particular technology or system, may enhance their performance (Hong et al., 2006). It measures the individual's subjective evaluation of the functionality and efficiency offered by the innovation under a specific task related context (Hu et al., 1999). While perceived usefulness was initially defined in relation to job performance, the definition now encompasses the performance of generic tasks in various different settings by both animate and inanimate objects (Marangunić & Granić, 2015). Attitude towards use is defined as the extent to which an individual associates and positively evaluates the targeted technology in relation to their job or task demands (Silva, 2015).

A major factor that impacts an individual's intention to use or adopt a technology is the ATU. This is affected by PU and PEOU which are based on the major beliefs of the individual (Ibrahim et al., 2017). Ultimately, the individual makes a calculated estimate regarding the merits of a particular technology which will lead them to decide if the new technology should be adopted or not (Doanh et al., 2022). Inherent in this is the lack of control that the individual has over the ease of use and usefulness of the technology along with the lack of information about the new technology (Hu et al., 1999). Due to the vulnerability of the adopter along with their lack of control and information, they are required to take a *leap of faith* when deciding to adopt a new technology (Hong et al., 2006). While usefulness and ease of use are necessary for the adoption of an innovation, trust in the innovation and in its provider is highly important in determining the decision to adopt. Within this paper, the aforementioned *leap of faith* will be termed trust.

2.9.1 TAM-Trust Model

Pavlou (2003) proposes a new model of TAM that broadens the context by introducing trust as a contributing factor in the adoption of an innovation. As previously mentioned, new technologies feature a particular level of perceived risk, uncertainty, and vulnerability ultimately emphasising the relevance of trust in the process. Trust is a crucial element of most relationships and interactions particularly in those that contain an element of risk and often determines the nature of social orders and interactions (Kim, 2012).

Trust is defined as the belief that an individual holds regarding the behaviour of another entity, particularly that the other entity will behave in a dependable and ethical manner (Tsai et al., 2010). Uche et al. (2020) adds to this and asserts that trust is the expectation that an entity (that one chooses to trust) will behave in a reliable manner and will fulfil its expectations and commitments regardless of the vulnerability and dependence of the trusting party. It further encompasses the notion that the trusted entity will fulfil its obligations and commitments regardless of the individual's vulnerability and dependence (Tung et al., 2008). Various theories have agreed that there is no universally accepted definition of trust as it is highly contextual. However, there has been consensus that vulnerability and uncertainty are necessary and sufficient prerequisites of trust (Kim, 2012). Trust would not be necessary under conditions of complete certainty. The existence of uncertainty creates the conditions of vulnerability (Julsrud & Krogstad, 2020). The adopter operates in an uncertain environment, therefore, their knowledge and perceptions regarding the technology and its providers are incomplete (Tung et al., 2008). This ultimately creates vulnerability for the individual and ultimately results in trust becoming necessary for the adoption of the technology.

Prior to adopting a technology, the adopter should evaluate the trustworthiness of the technology based on its characteristics as well as the characteristics of the providers of the technology (McCloskey, 2006). Generally, this includes aspects such as guarantees and services that attest to the trustworthiness of the innovation. In the instance of SFs, aspects such as accuracy of the forecasted information, reliability, and the credentials of the scientists and academics who develop the SF may all positively influence the trustworthiness of the SF. Various research studies on interpersonal relationships have theorised that the development of trust is gradual (McCloskey, 2006). Some studies, however, have cited high initial trust which is weighted by perceived risks and derived from a calculus of losses and gains (Davis, 1989). This, however, does not account for the role that human emotion plays in trust (Chauhan, 2015). Bahmanziari et al. (2003) puts forth the idea of institution-based trust (IBT). IBT highlights the

security that individual's feel regarding a particular situation due to certain safety nets, guarantees, or other trust structures (Bahmanziari et al., 2003). IBT aids in explaining the prevalence of high initial trust between unfamiliar parties and consists of structural assurance beliefs (SAB) and situation normality beliefs (SNB) (Davis, 1989). SAB includes structural safety nets such as guarantees and regulations that would allow the adopter to relieve some of the risks associated with the innovation (Davis, 1989). In relation to new technologies, this may include customer services, training, or return policies (Agarwal & Karahanna, 2000). SNB arises as a result of the trustors beliefs that a situation or entity is normal (Gefen et al., 2003). In the context of new innovations, this encompasses the adopter comparing the innovation to other technologies that they are familiar with or may have used in the past (Chauhan, 2015).

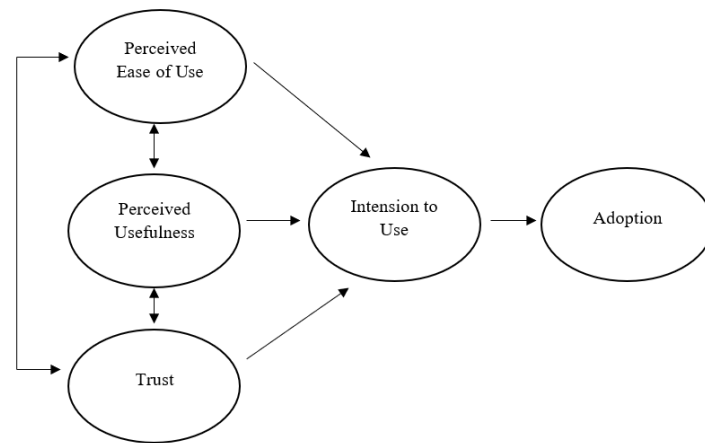


Figure 4 TAM-Trust Model of Adoption.

2.9.2 Adoption and Implementation of SFs

Current shifting climate conditions coupled with the urgency of mitigation measures and agricultural adaptation has enhanced the need for collective action and effective behavioural change. Information on shifting climate conditions is central to adaptation responses. Such information is particularly important in production sectors where actors are dependent on their environments. Access to information regarding cutting-edge agricultural systems are highly important for enhancing production and overall development of the agricultural sector (Hudson et al., 2011). As a result, a forecast of monthly and weekly rainfall is inherently useful to farmers. Forecasts are used to aid decision makers regarding when to plant crops based on rainfall patterns for the season and further allow farmers to prepare for potential seasonal changes so that they are able to enhance their water management and conservation techniques.

Forecasting information in the agricultural sector is particularly useful for water management, flexibility in farming practices, and within-season decision making such as scheduling of planting, crop selection, and harvesting (Hudson et al., 2011). Seasonal Forecasts are proposed as a way of reducing the risks associated with agricultural production. The implementation of SFs should then enhance the profitability of agricultural practices through reducing losses in drier seasons or increasing the farmer's overall gains.

This study is therefore aimed at determining the improvements that are necessary to encourage South African agricultural experts and farmers to voluntarily adopt SFs in their farming practices. The main objective is to understand the different hindrances or motivators of the adoption of SFs in the Eastern Cape and the Western Cape. The study is then aimed at understanding farmers' perceptions, beliefs, and experiences surrounding the adoption and implementation of SFs which may ultimately lead to their greater use. The study was further aimed at understanding the various similarities and differences in perceptions that may arise between Eastern Cape and Western Cape farmers in order to gain a more holistic understanding of farmers' insights. In this regard, the following questions were considered:

1. What were (Eastern Cape and Western Cape) farmers' and agricultural experts' perceptions regarding the perceived ease of use (understandability) of the SF information?
2. What were (Eastern Cape and Western Cape) farmers' and agricultural experts' perceptions regarding the perceived usefulness of the SFs?
3. How likely were (Eastern Cape and Western Cape) farmers' and agricultural experts' to trust the information provided by SFs?
4. Do the perceptions between the two groups of farmers align?

Chapter 3

Methods

3.1 Research Design

A qualitative research design was used within the study. Qualitative research examines the complexities of phenomena that cannot be quantified into numerical representations (Pathak et al., 2013). It further aims to address questions concerned with understanding the creation of experiences and meaning within human lives and the social world at large (Pathak et al., 2013). The idea of illuminating participant's subjective social contexts, actions, and meanings (as understood by them) is central to qualitative research (Pathak et al., 2013).

The term paradigm describes different world views or systems of ideas used by a society to generate knowledge and represent different ways of measuring and observing phenomena (Wilson, 2017). Within the context of this research, an interpretivist paradigm was adopted as it accounts for the meaning of individual actions and experiences, and further focuses on understanding. The nature of the question is therefore interpretive, as it aims to examine how farmers understand and make sense of SFs outputs. Furthermore, a cross-sectional research design will be implemented as participants were only studied at one point in time (Olsen & St George, 2004).

One of the main concerns in this approach is the maintenance of rigour of the research. This is done by ensuring that the interpretation of the data is well grounded, while also paying attention to subjectivity (which refers to the farmers' individual voices) and reflexivity (discussed below). Additionally, it is important to make use of communication that is clear and applicable to the findings of the study.

The research study is focused on understanding farmers' perceptions of SFs. This falls within the domains of phenomenology (Fossey et al., 2002). Phenomenological research focuses on the study of ordinary lived experiences and is interested in examining how individuals experience the world and the best ways in which researchers can understand their experiences (Fossey et al., 2002). The study is part of a multi-disciplinary, multi-institutional, broader research study and was conducted in order to provide more information regarding the farmers' perceptions of SFs.

3.2 Sample and Sampling

A non-probability, purposive, convenience sample was utilized within the study. This particular sampling technique was utilized as only individuals that align with the proposed criteria and are considered representative enough of the proposed sample were included (Laher & Botha, 2012). The sample was selected from the EC and WC provinces of South Africa as the researcher wanted a combination of small-hold and commercial farmers. Furthermore, members of the research team were from Universities in the EC and WC region and were therefore able to conveniently access the sample. A sample was accessed with the help of the research team, and two South African agricultural corporations; Overberg-Agri (in the Western Cape) and GrainSA (in the Eastern Cape). Overberg-Agri and GrainSA aided the researcher in identifying a convenience sample which consisted of commercial farmers in the WC and small hold subsistence farmers in the EC respectively. Participants were invited by the researcher to voluntarily participate. Focus group workshops were conducted at a (mutually) convenient location and time.

The sample consisted of 150 participants aged between 40 and 70 years old. More than half the participants were men (63.3%). Furthermore, 64% of the sample identified as Black while 36% identified as White. All of the participants from Bizana, Maclear, Mount Ayliff and Mount Fletcher identified as Black whereas all the participants from Caledon and Moorreesburg identified as White.

Table 1 *Demographics of Sample*

		N	Percent
Location			
Western Cape	Moorreesburg	22	14.7
	Caledon	32	21.3
Eastern Cape	Bizana	23	15.3
	Maclear	23	15.3
	Mount Ayliff	19	12.7
	Mount Fletcher	31	20.7
	Total	150	100.0
Gender			
	Female	55	36.7
	Male	95	63.3
	Total	150	100.0
Race			
	Black	96	64.0

White	54	36.0
Total	150	100.0

3.3 Data Collection and Procedure

A Non-Medical Research Ethics clearance form was submitted to the University of the Witwatersrand, Human Research Ethics Committee, stipulating the procedure and ethical conduct during this research project. Such clearance was obtained prior to data collection (see Appendix A). Participant information sheets and informed consent forms were provided to participants prior to data collection (see Appendix C & D). Participants were informed about the purpose of the study, the procedure of data collection, and the analysis of the results. Data collection was conducted using six focus group sessions with various stakeholders including farmers, agricultural experts and extension officers. The focus groups were held in Caledon and Moorreesburg (WC) in July 2022 as well as in Bizana, Maclear, Mount Ayliff, and Mount Fletcher (EC) in November 2022. Focus groups were open discussions among 19 and 32 people. The topics focused on farmers' perceptions regarding the trustworthiness, usefulness, and understandability of the SFs. Focus group participants ranged from large-scale commercial farmers in the WC to small-scale subsistence farmers in the EC. The participants were invited to voluntarily participate in the workshops through the help of Overberg-Agri in the WC and GrainSA in the EC.

A Participant Information Sheet and Informed Consent forms for the focus group were distributed and signed by participants prior to conducting the focus group (see Appendix C & D). They were also given an explanation regarding the purpose of the research. This allowed the participants to familiarise themselves with the study. The workshops consisted of two phases. The first phase consisted of a group session where SFs were explained to the farmers. The presenter introduced the seasonal forecast (what it is and how it can be used) and further highlighted what the study was trying to achieve. This was done in a different format in the WC and the EC. In the WC the SFs were explained as a PowerPoint presentation (see Appendix E) whereas in the EC the SFs were explained using cartoons that were developed by the research team to explain SFs (see Appendix F). This was done because (a) it was anticipated that there would be no electricity at the focus group sites in the EC to run the PowerPoint presentation; (b) educational levels of the EC farmers were expected to be significantly lower than the WC farmers; and (c) language barriers might have been a problem in the EC. The

second phase asked farmers to provide information regarding what they would like to see in a SF, how they would use it, how useful they thought it was, and what would enhance the usefulness of the forecasts. This allowed the researcher to engage with participants as a way of gaining insight regarding the different detailed experiences of participants in relation to the SF information.

3.4 Instruments

Qualitative focus group sessions were conducted using open-ended questions. A discussion manual was developed by the researchers in order to facilitate and moderate the discussion. The manual was structured around two central areas: (i) farmers perceptions regarding the usefulness, understandability, and trustworthiness of the forecasts and (ii) how scientists could enhance the usefulness, understandability, and trustworthiness of the forecasts. The moderator used questions and prompts to facilitate and generate the discussion. As a way of ensuring the robustness of the data, multiple strategies were utilized including rephrasing and expansion of questions and a summary of the various discussion points provided by previous research to which participants were encouraged to expand on or agree with. At the end of the discussion, the researcher summarised all key points and participants were given an opportunity to add comments to any areas that they felt had not been explored fully. Each focus group discussion lasted approximately 90 minutes.

3.5 Data Analysis

Data was analysed using Thematic Analysis (TA). Thematic analysis encompasses a set of techniques that report, analyse, and identify themes and patterns within the data (Braun & Clarke, 2019). TA provides support in communicating and systemising data into sets of detailed data themes (Braun & Clarke, 2019). This was used to interpret and highlight the ways in which farmers understood different presentations of SF's. Furthermore, TA was used to highlight the main themes generated from the responses of participants during the interview processes, this aided the researcher in understanding the lived experiences of farmers regarding their use of different SF outputs.

In order to facilitate the coding, the following was completed. The data was recorded by a devoted note-taker, translated into English where necessary, and checked for accuracy. The researcher then meaningfully assessed the transcriptions in order to identify elements of the raw data to generate codes, that was used as potential themes. After the coding process was completed, the researcher allocated codes into the relevant themes. The relationship between different themes was determined and allowed the researcher to allocate them into key themes

and subthemes. In order to ensure the coherence and validity of the themes, the generated themes were reviewed by the researcher. Once the researcher was satisfied with the themes generated, each theme was named and defined, and thereafter used within the TA report.

3.6 Ethical Considerations

Ethical clearance was obtained from the University of the Witwatersrand, Human Research Ethics Committee prior to data collection (see Appendix A). Participants were made aware that there were no direct costs or benefits involved with participation in the study and all participation was on a voluntary basis. Furthermore, they were made aware that there were no penalties for non-participation. Prior to conducting data collection, participation information sheets detailing the purpose of the study along with an informed consent form were provided to each participant (see Appendix C). The consent forms were filled out and signed prior to the focus group (see Appendix D). Details on the consent forms indicated that by signing the forms participants consented to participate in the study and for the workshop to be recorded (recordings were done by a dedicated note-taker and were not audio-recorded to protect the anonymity of the participants). In addition to this, at the time of the workshop, participants were verbally informed about the details and ethics of the study (including the finer details) such as data protection and confidentiality.

The written recording of the focus group session was accessible to the researcher and, her research supervisor. Transcribed notes of the focus group were available to the research team. Recordings and transcriptions were kept in an encrypted folder on the researcher's computer. Participants were instructed that they could choose to not answer any questions they felt uncomfortable with. Participants were also made aware of the fact that they could withdraw their responses or withdraw from the study at any time (Orb et al., 2001). Anonymity was not ensured during the data collection phase due to the method of data collection, namely face-to-face workshops and focus group discussions.

Demographic information was collected to aid in the description of the sample. All identifying characteristics (such as names and contact details) were left out of the final report. Hence, anonymity and confidentiality of all responses were maintained in the research report. Furthermore, participants were provided with contact details (on the participant information sheet) which they were allowed to keep should they have had any follow-up questions. Participants were advised that they could request a summary of the findings of the study. Lastly, any major discrepancies between the experts' and users' knowledge regarding the meaning of the SFs were addressed in the form of a debriefing at the end of the focus groups.

3.7 Maintaining Rigour

The researcher is generally the primary instrument for data collection within qualitative studies and therefore any researcher biases that are not adequately addressed may affect the quality of the data (Smith & McGannon, 2018). It is therefore imperative that the study adheres to high standards of rigour due to the contextually bound nature of qualitative data. Rigour is achieved when the methods of the study are systematic, transparent, and accurate reporting of results occurs (Smith & McGannon, 2018). Rigour consists of four main components credibility, transferability, dependability, and confirmability (McBrien, 2008). Credibility is discussed below in terms of rigour. This study ensured the transferability of the research findings by providing a dense description of sample population by describing the geographic boundaries and demographics of the study (Smith & McGannon, 2018). Furthermore, the transferability of the results was ensured as this study was part of a broader research study where similar methods of data collection were used with different demographic groups in different geographical locations. The study ensured dependability as a detailed description of the analysis process was provided (McBrien, 2008). Lastly, with regards to confirmability, the researcher documented the research process using a field journal. This contributed to the confirmability of the results as it incorporated notes regarding the researcher's biases, personal feelings, and insights (Smith & McGannon, 2018). Furthermore, this aided with the coding of the data. Lastly, the researcher's field notes were also used within the self-reflection process (McBrien, 2008).

3.8 Reflexivity

Reflexivity functions as a method of quality control within qualitative research (Jootun et al., 2009). Reflexivity is a key tenet of critical qualitative research and highlights the degree and extent of influence that researchers (intentionally or unintentionally) exert on their findings (Macbeth, 2001). The quality of the research is enhanced through its ability to highlight the ways in which the researchers' interests and positions impact on different stages of the research process (Dowling, 2006). Ultimately, it involves researchers understanding that they are contributing members of the social world that they are investigating. It is imperative that researchers consider the ways in which their beliefs, social positions, and personal experiences impact on their interpretation of qualitative records.

Within the study, the researcher functioned as the primary instrument of data collection. This may have influenced the interpretation of the participants' responses. In light of this, the researcher remained aware of any possible biases or pre-conceived ideas (that she may have)

that could potentially impact on her understanding of the participants' responses. Within the context of the study, the researcher's background knowledge mostly comprised of psychological concepts while the study further encompassed climate change and agricultural practices. As a result, the interviewer felt that they did not influence their responses as the participants were positioned as *experts* within the field. The researcher also practiced reflexivity in a number of ways; reflection on writing styles, development of field diaries and writing self-critical accounts as a way of noting any potential biases that may have impacted on the research.

Chapter 4

Results

This chapter aims to explore the various themes identified within the data. The process of thematic analysis that was applied to the transcripts elicited important concepts that were evident in the data. These themes are considered essential in determining the farmers' perceptions regarding SF information. This chapter reports the various themes identified from the analysis of the EC and WC workshops and further classifies them into themes and subthemes (see Table 2 & 3). The chapter will make use of the results of the analysis in order to provide a comprehensive understanding of farmers' and agricultural experts' perceptions towards SFs. The chapter will begin by discussing the various themes identified from the analysis of the EC, followed by the various themes that arose from the WC data. Quotations will be used in support of the various themes identified.

4.1 Eastern Cape

Various themes were identified from the analysis of the EC data. Each theme was split into subthemes and different codes. These are presented in Table 2 (below)

Table 2 Eastern Cape Themes and Codes

Theme	Subtheme	Code
Accessibility of the SF Information	Dissemination	Workshop
		Television & Radio
		Social Media
		Sharing Information
		Schools
		Phones & Texts
		Groups
		Extension Officer
		Apps/Internet
		Language Barrier
	Lack of Accessibility	Lack of Access
	Need for accessibility	Need for Access
Accuracy of the SF Information	Lack of Accuracy	Lack of Accuracy
	Accuracy	Accuracy
Preparation of farming Practices	Preparation of farming Practices	Animals
		Crops
		Insurance
		Fields
		Planting Time
		Soil
		Preparing for Uncertainty

Climate Uncertainty	Climate Uncertainty (not useful)	Climate Information
		Weather Forecast
Risk Aversion	Risk Aversion	Decision Making
		Risk Aversion
Factors that Enhanced the Usefulness of SFs	Time Frame of the SF	Long Term
	Forecasted Climate Conditions that Enhanced the Usefulness of SFs	Temperature
		Frequency
		Intensity
		Rain
	Information Regarding Extreme Conditions	Too Wet
		Floods
		Hail
		Wind
		Heat
	Localisation of the SFs	Crop Damage
		Localisation Specification
Factors that Reduced Usefulness of SFs	Farmers Continue to Plant	Farmers Continue to Plant
Factors that Enhanced Farmers Trust in SFs	Experience	Experience
	Increases Trust	Increases Trust
Factors that Reduced Farmers Trust in SFs	Uncertainty	Uncertainty
	Gamble	Gamble
	Lack of Trust in Scientific Knowledge	Lack of Trust in Scientific Knowledge
	Risks	Risks
Factors that Enhanced Farmers Understandability of the SFs	Training	Training
	Presentation	Narrative Format
		Oral Presentation
Factors that Reduced Farmers Understanding of the SFs	Stories	Stories
	Presentation	No Picture
Resources Available to Farmers	Lack of Understanding	Complexity
		Hope
		Indigenous Knowledge

4.1.1 Accessibility of the SF information

The theme of accessibility included three subthemes: a lack of accessibility of the SFs, a need for accessibility of the SFs, and the dissemination of SF information. When assessing a lack of accessibility, various farmers indicated that they had access to weather forecasts but not SFs. They further stated that they wished to have better access to SF information. Additionally, farmers were interested in knowing where they could receive the information from as they believed it could help them with their planting time. One farmer noted that there was a local weather radio station, but the local extension services did not provide access to SF information. Another farmer indicated that their area lacked the resources and technology needed to help them make decisions. The majority of farmers asserted that they did not have internet access

and were therefore unable to access any SFs using the Internet or any of the related online services.

“Most farmers have access to weather forecasts on the radio but not seasonal forecasts.”

(Mount Fletcher)

“We wish to have better access to seasonal forecast information.” (Maclear)

“Where can we get SF information from the internet (website)?” (Mount Fletcher)

When examining the need for accessibility of SF information, the farmers wanted to know where and how they could access the information. From all the workshops, only one farmer indicated that she had access to SF information. The subtheme of accessibility also encompassed the dissemination of information. Farmers provided various ideas regarding how the information could be provided to them in a more accessible way. One farmer thought that GrainSA should encourage SF workshops with farmers. Another farmer indicated that the information should be distributed to extension officers who could then relay the relevant information to them, and that this should preferably be carried out before the planting season. The sharing of information emerged as an important idea with various small-hold farmers indicating that they could receive the information from local commercial farmers. Another farmer indicated that one individual should be elected to receive the information from the scientists, and they could then share the information with other farmers.

“Sharing SF information from one farmer to another.” (Maclear)

Farmers also thought that SF information could be disseminated through schools. One farmer indicated that the scientists should share the SF with local primary and high schools and the farmers could receive the information from them. This was echoed by another farmer who indicated that both schools and local clinics could be used.

“Use schools and clinics, as gathering points to distribute information in remote locations quarterly.” (Maclear)

In line with this, farmers indicated that SF information should be sent to extension officers who would distribute it to the farmers. One farmer indicated that the information should be sent to the extension officers as the farmers preferred to receive the information from them. Another farmer indicated that the extension officers should ensure that remote communities have access to the information. A second farmer advised that the information should be displayed at

extension offices where agricultural meetings are usually held. He further stated that the information could be presented on calendars or catalogues. All the farmers agreed that farm groups were vital and stated that the information would be shared between farmers at the farm group meetings.

All farmers agreed that the information should be disseminated using some form of technology. This included television, radio, social media, and texts. The farmers indicated that they currently only received weather information from radio and television channels. One farmer however indicated that SFs could be broadcast on the local farmer's channel. Another farmer added to this and stated that SFs could also be shared on local radio stations. This was echoed by another participant who indicated that the information could be broadcast on their community radio services. A second group of farmers urged the scientists to distribute the information using WhatsApp and other social media platforms such as Facebook.

“Information can be provided via WhatsApp in the form of notes or stories.” (Mount Ayloff)

Contrary to the aforementioned group of farmers, a third group indicated that they did not have access to WhatsApp or any other social media platforms and felt that the information should be distributed through text messages. They further added that distributing information through social media has many challenges associated with accessibility due to network issues in their remote communities. One farmer indicated that social media could be used to complement text message information.

One participant proposed asking children and teenagers to help them access the information from the internet. A younger farmer proposed the idea of a SF App (for a mobile phone). Lastly, the farmers mentioned that the language barrier reduced their accessibility and stated that the SF information should be disseminated in isiXhosa. One farmer asserted that she would prefer to receive the information in local languages such as isiXhosa, isiZulu, or seSotho.

“The information is extremely useful, but it should be explained in Xhosa.” (Bizana)

4.1.2 Accuracy of the SFs

The theme of “accuracy” consisted of a lack of accuracy of the SFs and the need for enhanced accuracy. Various farmers voiced that they experienced crop loss due to inaccurate SFs.

*“We experienced losses in terms of crops as the information we received was not accurate.”
(Maclear)*

The farmers unanimously agreed that enhanced accuracy regarding SF information would enhance their trustworthiness. One farmer noted that SFs only aid in preparation if the information provided is accurate. This was echoed by another farmer who indicated that precise information would be highly beneficial because they do not use irrigation, if they plant and it does not rain, they will not receive any crops for that season. One participant indicated that SFs were only useful if the prediction actually occurs. This highlights that the usefulness of SFs is dependent on their accuracy. Another farmer noted that the reduction of uncertainty regarding the actual occurrence of a predicted climate event may improve the decision making of the farmers.

4.1.3 Preparation for Farming Practices

The subtheme of “preparation” included various areas of preparation that SFs could aid farmers in. This included animals, crops, fields, insurance, planting time, soil, and preparing for uncertainty. Various farmers indicated that SFs could aid farmers in preparing their livestock for the upcoming season. One farmer noted that SFs could aid her in determining the number of animals to keep for the season. Another farmer added that SF information would aid her in deciding if she would need to acquire supplement feeds for her livestock for the upcoming season. A third farmer indicated that the information would be beneficial for protecting their livestock particularly if a forecast indicated snow.

“Seasonal forecasts could help determine the number of animals to keep.” (Maclear)

Another important area of preparation would be crops. The farmers agreed that SF information would be highly beneficial in preparing their crops. This was linked to crop varieties and preparing the crops for extreme conditions. Various farmers indicated that SFs would aid them in determining what type of cultivar to plant. The farmers indicated that different crops require different weather conditions therefore they needed SFs to determine the best type of crops to plant for that season. They indicated that this was particularly important for maize crops. The farmers explained that using different crop varieties was highly important under specific conditions. They indicated that they would plant early maturing crops if the SF indicated snow because this would mean that winter would be starting earlier that season. One farmer added to this and stated that he needed information regarding hail, so that if the forecast indicates hail, he would be able to switch to hail resistant crops such as cabbages and potatoes. A second farmer indicated that they could use the SFs to prepare for hot seasons as some plants often do not germinate during these conditions. One farmer indicated that precise SFs were highly

important particularly regarding information on rain. She stated that they did not utilize irrigation therefore if they planted and it did not rain, they would not get any crops.

“Seasonal forecasts could be valuable in determining the type of cultivar to plant depending on the situation.” (Maclear)

Another farmer indicated the SFs were beneficial when preparing their fields for planting. She stated that they cannot plough the land if it does not rain, therefore they require rain. She, however, added that the amount and frequency of rain was highly important because the rain needs to stop before the planting season, or they would not be able to plough as the ground would be too wet and muddy. One farmer indicated that she used weather forecasts for her soil preparation. She further indicated that soil preparation would not be advantageous on a 70/30 SF basis. A 70 to 30 odds indicates that out of 100 possible outcomes, the odds are that 70 indicates it would rain and 30 indicates it would not rain. Therefore, there is a 70% probability it may rain and a 30% probability it may not rain. Another farmer highlighted that soil preparation was highly expensive because they prepared between ten to twenty hectares of land, therefore information regarding the upcoming season was highly beneficial for cost-saving measures. The farmers indicated that when rain was common between August and September, they immediately began preparing the soil.

“We prepare for the upcoming season. If you say it’s wet, I can prepare my soil.” (Mount Ayliff)

The farmers unanimously agreed that SFs would aid them in determining when to plant their specific crops. They added to this and stated that SFs would allow them to determine if they should plant before or after a particular climate event. One farmer stated that she used weather forecasts to determine when to plant her vegetables and other crops. This was echoed by another farmer who indicated that he used weather forecasts to help him ready himself for the dry season. A participant indicated that farmers often plant thinking about what will happen in the future, so they therefore plant before they think it will rain. Therefore, SFs are important in telling them when they should be preparing to plant. Additionally, farmers stated that they could use the SF information to stagger their planting, and would then plant either before or after it rains depending on the SF. The farmers felt that SF information would aid them in preparing for uncertainty, this was also linked to insurance.

“Could possibly plant later or plant in seasonal time frames.” (Bizana)

“Seasonal Forecasts are helpful, can prepare using insurance.” (Mount Ayliff)

The overall concern for farmers was based on how they could prepare for uncertainty using the SFs. The vast majority of EC farmers within the workshops stated that the SF information was highly beneficial in preparing for uncertainty. One farmer indicated that she would use SF information to decide if she needed to purchase insurance for the upcoming season or not. Another farmer further explained that SFs were highly beneficial for financial planning. She stated that if they planned inappropriately and the season was either too wet or too dry then they would face excessive losses. Therefore, SFs would aid them in determining if they should buy the insurance.

4.1.4 Climate Uncertainty

Within this sub-theme, farmers indicated various conditions and circumstances regarding when climate information would not be useful. The farmers indicated that they did not consider SFs to be useful as the climate could change at any time. They further stated that climate change caused multiple uncertainties and therefore SF uncertainty was unavoidable. Therefore, due to its high levels of uncertainty, they did not necessarily perceive the SF information as useful. One farmer elaborated on this, he stated that when he was younger, he believed in seasons, however, climate change has altered seasons drastically therefore he was forced to believe in weather over climate. This was linked to a lack of usefulness regarding SFs.

“Didn’t think SF is useful because seasons are changing.” (Mount Ayliff)

4.1.5 Risk Aversion

Decision making and how SFs would impact decision making emerged as an important theme. This theme encompassed risk aversion. The farmers agreed that SF information and knowledge regarding the climate was good for decision making as it was better than not having any information. They indicated that this would help them in planning ahead. One farmer elaborated on this and stated that, SFs could aid them in decision making as receiving SF information well in advance was better than receiving two-week weather forecasts. Another farmer indicated that it would affect his decision making when planning. Ebhuoma (2020) states that access to future climate events can aid farmers in adapting efficiently by ensuring that they make better decisions during their agricultural practices.

“Acting on information is better than not having any information as this helps in improving production.” (Maclear)

The farmers also linked the usefulness of SFs when decision making to risk aversion. They indicated that they needed the information before their summer planting date, 15 December, in order to avoid losses due to frost and storms (later in the end of the season). This should be done so that they were able to minimise the risks associated with climate conditions. One farmer further proposed that the risks associated with SFs should be specific and should be put forward before they decide to use SF information.

“Risks must be put forward & needs to be specific.” (Bizana)

4.1.6 Factors that Enhanced the Usefulness of SFs

Having explained why they perceived the SFs as less useful. The farmers provided various areas of improvement that could enhance the usefulness of SFs. This was linked to the forecasting time frames, conditions of the climate, extreme conditions, as well as the localisation and specification of SFs.

4.1.6.1 Timeframe of the SF

Various farmers indicated that the SF time frame was highly important in enhancing its usefulness. Various farmers indicated that they needed SF information three months before their planting season. One farmer added to this and stated that they needed this information before a specified time period so that they were better able to plant on time usually around the end of August. Another farmer indicated that she usually plants around November, however, she might delay planting due to high rainfall. She stated that the distribution of SF information should be provided in November or latest the first week of December. This was echoed by another farmer who stated that if the rain fell later, he delayed planting until mid-December in order to avoid losses. One particular farmer provided different time frames for when she required the SF information based on different crop varieties. She asserted that she would need SF information in August for when she plants cabbage, October or November for maize, and January or February for beans.

“Need planting date before the 15 December, especially to avoid losses due to storms and frost. Some other farmers would suggest before 20 November.” (Maclear)

4.1.6.2 Forecasted Climate Conditions that Enhanced the Usefulness of SFs

Information regarding other conditions also emerged as a theme that would enhance the usefulness of SFs. One farmer indicated information regarding the temperatures of the upcoming season were highly important and should be added to the SF. Another farmer indicated that the frequency of when they receive SF information was also important. She

added that she would like to receive updated SFs bi-monthly. Another farmer suggested that the intensity of rain and other forecasts is also highly important.

“We want to know how much rain.” (Bizana)

Rain and any information relating to it, emerged as a prevalent factor that would enhance the usefulness of SFs. Various farmers asserted that they did not use irrigation, therefore any information regarding rainfall was highly important as they were dependent on it for successful harvests. It is important to note however, that the farmers indicated that excessive rain was also highly problematic. One farmer elaborated on this; excessive rain negatively affected crop growth as it caused the roots to rot. Another farmer indicated that information regarding rainfall was highly important as they could not plough their lands if it did not rain. Lastly, all the farmers agreed that they needed rainfall to plant, however it should not be continuous heavy rain. Hence, the farmers asserted that SFs would be useful in knowing if the forecasts indicated excessive rain.

“We just want to know if there will be rain or not.” (Mount Aylyff)

4.1.6.3 Information Regarding Extreme Conditions

The farmers highlighted various different extreme conditions and why information on extreme conditions would be inherently important. As mentioned previously, the farmers noted that excessive rainfall damaged crops and was therefore a condition that they should be aware of. The farmers indicated that too much rainfall caused certain crops, such as potato, maize, and cabbage, to rot. They further added that it results in uncontrollable weeds on their fields and noted that as a result they were unable to control what actually grows on their land. One farmer asserted that the weeds cannot be controlled with a tractor, and they were therefore forced to rely on pesticides. Another farmer mentioned that excessive water supply also resulted in crop diseases (e.g., fungus) and at times even attracted locusts that destroyed crops.

In relation to this, various farmers indicated that they would like to receive SF information regarding flood warnings as this would enhance their usefulness. One farmer stated that floods washed away their planted seeds and caused soil erosion which ultimately destroyed their harvests. A second farmer added to this and suggested that SFs should provide information regarding hail. She explained that hailstorms damaged their crops, and they therefore needed such information so that they can prepare and protect their crops from damage. Another participant indicated that if there were hailstorms during the December period, there was a chance that their crops may regrow. They however needed such information to prepare.

“If hail is in December, crops can still grow again.” (Mount Aylyff)

One farmer indicated that she would like to receive information regarding wind conditions as this may cause veld fires which were a large hazard to her crops. Another participant noted that information regarding heat was also important as excessive temperatures may cause heat damage to crops if the climate becomes too dry. Ultimately, the farmers agreed that SFs should provide them with extreme climate conditions so that they can use this information to prepare their crops accordingly.

4.1.6.4 Localisation of SFs

Farmers further asserted that the localisation and specification of SF information would enhance their usefulness. One farmer stated that the locality of the SFs generally did not cover the entire area. Another farmer added to this and indicated that SFs should be localised to determine the differences in climate between locations. She further added that differences in the climate of specific areas had significant impacts on the uncertainty of the forecast. A third farmer indicated that they were currently receiving weather information based on the Umtata weather station and they would therefore prefer to receive SF information based on Mount Fletcher. The SFs presented to farmers were at a provincial level and did not indicate information regarding specific localities.

“We would prefer if the weather and seasonal forecast information can be downscaled to our local scale.” (Mount Fletcher)

All the farmers agreed that the SF information should be more specific to their area. They stated that the area covered by the SF should be downscaled to a local area (e.g., Bizana or smaller) and should be more specific in relation to location. One farmer specified that she did not want SF information on the overall area, she needed to know the climate conditions of different areas in the region she resided in (she lived in Bizana but areas such as East or West Bizana had different conditions). Another farmer highlighted that she would like a zoom feature on the map so that she was able to zoom into a particular area to see the SF for that area.

*“Different areas in Bizana get different weather conditions therefore it needs to be specific.”
(Bizana)*

“The coast is wetter than inland, and hills make a difference.” (Bizana)

4.1.7 Factors that Reduced the Usefulness of the SFs

As mentioned above, the farmers stated that climate uncertainties reduced the usefulness of SFs. In line with this, one farmer indicated that he would continue to plant regardless of the SF information as they needed to plant before it rained. Another farmer elaborated on the previous statement and added that they could not plant later than their normal time frame due to crop rotations and other climate conditions such as frost or snow, therefore they had to plant regardless of the SF.

4.1.8 Factors that Enhanced Farmers Trust in SFs

Farmers identified various different elements of the SF information that enhanced their trust. This was also linked to their experiences with SFs. Most farmers agreed that their previous experiences with forecasting information determined how likely they were to trust the SF. Furthermore, many participants indicated that the forecast needed to be correct the first time in order to enhance their trust. Another farmer indicated that, he would only trust the forecast if it aligned with his indigenous knowledge of the area.

“Trust will be based on good experiences with SFs. The greater the number of times it is correct, the more we will trust it.” (Bizana)

They further indicated that they were more likely to trust a forecast if its predictions were correct more than 50% of the time. Farmers in Mount Ayliff indicated that the forecast needed to be correct five out of nine times in order to ensure their trust. This contradicted with farmers from Bizana, who indicated that their trust would only be ensured if the forecast was correct six out of nine times. Alexander and Block (2022) note that correctness and precision have a large impact on farmers trust in SFs.

“6 out of 9 times correct to ensure trust.” (Bizana)

4.1.9 Factors that Reduced Farmers Trust in SFs

Various elements that reduced farmers trust in SFs were mentioned. This included uncertainty regarding the SF, their perceptions of the SF information being a gamble, a lack of trust in scientific knowledge, and the risks associated with using the SF.

4.1.9.1 Uncertainty

Many farmers cited uncertainty as a leading factor that reduced their trust in SFs. This was due to high levels of uncertainty provided by the SF regarding climate conditions. One farmer indicated that climate uncertainty differed across years and seasons. This reduces the likelihood of the information being correct and ultimately decreased their trust in the SF. Another farmer

indicated that SFs did not provide enough certainty for them to actually alter their farming practices.

“Many chances for uncertainty” (Mount Fletcher)

4.1.9.2 Gamble

Linked to the uncertainty mentioned above, farmers likened lower probabilities regarding the likelihood of a particular climate condition to gambling as there was no certainty regarding the occurrence of a particular condition. One farmer equated SF information with guessing climate conditions and asserted that the uncertainty surrounding it closely resembled gambling.

“Are you telling us not to believe in science because you're guessing?” (Mount Aylyff)

“It is a gamble.” (Bizana)

4.1.9.3 Lack of Trust in Scientific Knowledge

Lack of trust emerged as the prominent discourse surrounding SFs. This was linked to a lack of trust regarding the SF information, the scientists, the science itself and their previous experiences with forecasting. The majority of farmers indicated that they didn't fully trust the information provided by SFs. They further noted that they didn't trust the accuracy of the SF especially if the information provided was wrong the first time. They were less inclined to trust it in the future.

“So many times, we were told the rain is coming but it didn't. Therefore, we don't trust it.”

(Mount Aylyff)

One particular farmer noted that he did not trust weather forecasts because very often they predicted rain, but the forecast did not materialise. Another farmer stated that he was less inclined to trust forecasting information that predicted climate events further into the future. He stated that farmers trusted weather forecasts in the moment and not for the future. His thoughts were echoed by other farmers who indicated that they only trusted forecasts when its predictions materialised. Various farmers indicated that they did not trust the potential of the scientists and their climate predictions. They further stated that scientists often did not accurately predict conditions and therefore they were unable to trust the scientists. Furthermore, most farmers did not necessarily believe in science or scientific knowledge and therefore were less inclined to trust it. This was contradicted by another participant who indicated that he wanted to be convinced to believe in science. Additionally, one farmer thought the idea of a SF was hilarious and did not believe it was possible to make such predictions.

“It is very funny to me, how can you predict the climate?” (Mount Ayliff)

“I want to be convinced to believe in science.” (Mount Ayliff)

4.1.9.4 Risks

The risks associated with implementing the SF information was another factor that reduced farmers’ trust. Farmers stated that in order to enhance their trust in SFs all risks associated with implementing SFs needed to be brought to their attention and should be further specified. This would enable them to make holistic decisions regarding the information provided.

4.1.10 Factors that Enhanced Farmers Understanding of the SFs

Farmers noted the different aspects of the SFs that enhanced their understanding. This included the adaptations that scientists could make in order to enhance their understanding and was linked to the presentation of SF information as well as various training initiatives. Regarding the presentation of the SF information, farmers indicated that oral presentations and presentations using a narrative format were the simplest to understand. All the farmers agreed that an oral presentation of information was the easiest to understand and they therefore preferred this format.

“We would like an oral presentation from scientists.” (Mount Ayliff)

One farmer indicated that having the information written out enhanced her understanding. This was echoed by a few other farmers who highlighted that a narrative format was better than a picture format. Farmers further likened the narrative format to a story with various farmers indicating that a story format was easiest to understand.

“Writing is better.” (Bizana)

“Story is much easier.” (Bizana)

After explaining their perceptions of the different presentations, the farmers referred to training individuals to interpret the SFs and indicated that this would immensely enhance their understanding. They suggested the use of an intermediary to communicate the information meaningfully. One farmer put forward the idea of a ‘leader farmer’. Other farmers indicated that training extension officers would be highly useful. Farmers stated that the scientists should hold workshops that educate the extension officers regarding the SF information and should further guide them regarding the interpretation of each forecast. This thought was shared by extension officers who indicated they should be equipped with knowledge of the SF so that they were better able to assist the farmers. Another participant suggested that young farmers

should engage with the scientists so that they were able to communicate SF information to older farmers in a more useful and understandable way. One farmer suggested training regarding map interpretations.

“Need professional help on utilizing seasonal forecasting information (some farmers can be trained to train other farmers).” (Maclear)

4.1.11 Factors that Reduced Farmers Understanding of the SFs

Having explained the various aspects of the SF information that enhanced their understanding, farmers thereafter noted the different aspects of SFs that reduced their understanding. This was linked to the presentation of the information and the complexity of the information provided. Multiple farmers indicated that they did not appreciate the picture presentation of SFs as it was difficult to interpret.

“Pictures of maps are the worst.” (Bizana)

Farmers also cited that the high levels of complexity regarding the interpretation of the forecasting information further reduced their understanding. One farmer indicated that he felt there was a need for the information to be communicated in a more simplified manner. This was echoed by another farmer who stated that most older farmers did not understand the information regardless of how they received it. He further added that they may need professional help in order to interpret and use the information provided by SFs.

“Have trained people to simplify (interpret) forecasts information better (as most old farmers do not understand the information even if it’s communicated via WhatsApp).” (Maclear)

4.1.12 Resources Available to Farmers

When examining the different resources that farmers were currently utilizing when dealing with climate uncertainty, hope and indigenous knowledge emerged as prevalent sub themes.

4.1.12.1 Hope

Hope emerged as a prevalent theme among the farmers. Various farmers indicated that they often just hoped for rain and waited on it before they began planting. Another farmer stated that they were always hopeful that it would rain.

“Very often we just hope and wait for the rain to come before we start planting and ploughing.” (Mount Ayliff)

4.1.12.2 Indigenous Knowledge

In addition to this, farmers also made mention of indigenous knowledge systems. Farmers used their indigenous knowledge to estimate the climate variability of the following season. One farmer indicated that snowfall in June or July would be indicative of rain in October or November, which was highly important for their crops. Another farmer indicated that he believed in his own knowledge of the environment and preferred it over scientific knowledge. This was echoed by other farmers who indicated that they believed in nature over science and depended on their knowledge and experience.

“We believe in nature not science.” (Mount Ayliff)

This was further emphasized by another participant who stated that she used indigenous knowledge to prepare against weather damage. She provided an example and claimed that they often mixed maize seeds with sea sand in order to protect against hail damage.

4.2 Western Cape

Various themes were identified from the analysis of the WC data. Each theme was split into subthemes and different codes. These are presented in Table 3 (below)

Table 3 Western Cape Themes and Codes

Theme	Subtheme	Code
Accessibility of the SF Information	Dissemination	App
		Website
		Language Barrier
	Need for Accessibility	Need for Accessibility
Accuracy of the SF	Lack of Accuracy	Lack of Accuracy
	Accuracy	Accuracy
Preparation of Farming Practices	Preparation of Farming Practices	Planning
		Planting Time
Farmers Perceptions of Climate Information	Farmers Perceptions of Climate Information	Weather Forecast
		Climate Uncertainty
Decision Making	Decision Making	Decision Making (useful)
		Risk Aversion
Factors that Enhanced the Usefulness of SFs	Time Frame of SFs	Long Term
		Short Term
		Temperature
	Forecasted Climate Conditions that Enhanced Usefulness	Distribution
		Frequency
		Rain
		Rain Distribution
		Extreme Forecast (not useful)
		Extreme Forecast (useful)

	Information Regarding Extreme Conditions	Heat
		Humidity
		Too wet
		Dry
		Wind
	Localisation of SFs	Localisation
		Specification
	Historical SF Information	History (not useful)
		History (useful)
Factors that Reduced the Usefulness of SFs	Continue to Plant	Continue to Plant
	Not Valuable	Not Valuable
Factors that Enhanced Farmers Trust in SFs	Experience	Experience
	Explanation	Explanation
	Source of Information	Source of Information
	Improves Trust	Improves Trust
Factors that Enhanced Farmers Understanding of SFs	Training	Training
	Presentation	Story/Narrative Format
		Point Form
		Percentage
	Simplification	Streamline Understanding
Factors that Reduced Farmers Understanding of SFs	Presentation	Not Narrative
		Not Map
		Not Probability
	Lack of Understanding	Complexity
		Info Overload
		Difficulty Understanding
Resources Available to Farmers		Hope
		Indigenous Knowledge

4.2.1 Accessibility of the SF information

Accessibility emerged as the first theme. The theme consisted of two sub-themes: the dissemination of SF information and a need for accessibility. The farmers provided various ideas and ways that forecasting information could be disseminated within their community. One farmer suggested the use of a mobile phone App. He stated that the information could be added to an App and updated every three hours. Another farmer suggested a website that was easily accessible to all farmers. The farmers also noted a language barrier and suggested that the information should be presented in Afrikaans.

4.2.2 Accuracy of the SFs

The theme, accuracy, incorporated both a need and a lack of accuracy of the SF and further determined farmers' perceptions regarding the accuracy of the information. When examining a lack of accuracy, the farmers stated that the SF should not be made less accurate by adding in extremes. Scientists use computer programs called climate models to develop SFs. Because information cannot be collected from the future, SFs generally use estimates to predict future climate conditions (Weisheimer & Palmer, 2014). The atmosphere is constantly changing therefore, the estimates become less reliable the further into the future you go, and the more

you add extreme events. One farmer indicated that the SFs provided a large quantity of information, but he was unsure of its accuracy. Another indicated that weather forecasts were often wrong therefore he was inclined to believe the same about SFs. Ultimately, the farmers were interested in knowing how often the forecasts were accurate and correct. The usefulness of the SF would be determined by its accuracy.

“How many times has the forecast been right?” (Moorreesburg)

In relation to the accuracy of the SF. The farmers noted that if the information provided was accurate, it would be considered useful. One farmer stated that if the SF was accurate once, he would be inclined to believe that it is reliable. Another farmer indicated that if the information for the previous month was accurate, it would be more useful. This statement was contradicted by one farmer who indicated that, unless there was a clear signal, the SF would not be useful. In order to ensure accuracy, the SF needs to be higher than a four out of five probability (almost 100% accurate). Ultimately, the farmers agreed that certainty was a requirement for usefulness.

“If it worked once, it’s probably more reliable.” (Moorreesburg)

4.2.3. Preparation for Farming Practices

Preparation is highly important when determining the usefulness of SFs. Farmers highlighted various instances when SFs would aid them in preparing for the upcoming season. The farmers agreed that planning was an important aspect of the planting season. They noted that SFs would aid them and be highly useful in planning ahead. One farmer added that he could use the SFs to make adjustments to his farming decisions overnight, which may have long term consequences. Another added that he would use it for marketing and stated that it would be easier to make advanced sales guarantees. A third farmer added that accurate SFs would aid him in planning for fertilization. All the farmers agreed however that the information would need to be provided early enough before the planting season for it to be useful (this will be assessed in more detail below).

“It is important during planting season as accurate predictions can help with planning.”

(Moorreesburg)

“Forecasts would be more useful at the beginning of the season.” (Caledon)

4.2.4. Perceptions of Climate Information

Climate information included the aspects of the SFs that farmers perceived as useful and those that they did not perceive as useful. One farmer indicated that SFs might not be as useful to

him as he utilizes weather forecasts, he added that he has to plant when its planting time regardless of the SF. Another farmer stated that weather forecasts have become more valuable over time to farmers, due to their improvement in skills and because farmers have learnt how to use the information to their advantage. He was optimistic that in time, farmers would also learn how to use SFs to their benefit. A second farmer added that SFs were useful to farmers as they cannot just rely on weather and needed to consider climate as well due to its uncertainty.

“We have to consider climate because there are various uncertainties.” (Moorreesburg)

4.2.5. Decision Making

The theme “decision making” highlighted various instances when the farmers perceived the SF as being useful. One farmer indicated that forecasting information would be useful when making decisions regarding contracts and marketing. This was echoed by a second farmer who indicated that he would use the information to make cultivation decisions as well decisions regarding the best crops to plant in the upcoming season. Another added that SFs could change decision making, if it predicted a dry season, he would plant less. The farmers further linked the SFs usefulness to risk aversion.

*“It would also be useful when making decisions regarding marketing and contracts.”
(Caledon)*

4.2.6 Factors that Enhanced the Usefulness of SFs

The farmers noted various different aspects of the SFs that would enhance its usefulness. They also proposed adjustments to the SFs that they thought would enhance the usefulness of the SF. This theme included time frames, climate conditions, extreme conditions, localisation, and history.

4.2.6.1 Timeframe of the SF

The farmers noted that the time frame and timing of the SF would either enhance or reduce their usefulness. They noted what they would prefer to see on the SFs in relation to timing. One farmer indicated that he would like to see long-term trends and fluctuations. He claimed that this was highly important when determining certainty. Another added that he would like to know how such trends influenced the SFs. Other farmers noted when they would like to receive the information and what it should include. One farmer stated that the further into the future the better, so that he is able to plan ahead. This was echoed by another who indicated that he would like information a year in advance. Another farmer noted that the information should be provided for a few months at a time.

“I want to know what will happen next year not next month.” (Caledon)

“The further out into the future forecasts are provided for the more potential value they would provide.” (Moorreesburg)

While the aforementioned farmers indicated they preferred long-term forecasting, other farmers contradicted them and voiced their preference for shorter term forecasting. One farmer indicated that monthly forecasting was more useful than three months. This was echoed by a second farmer who indicated that he would prefer daily forecasts over monthly forecasts. Another highlighted the importance of short-term planning.

“Shorter term forecasting (day-to-day) would be highly useful.” (Caledon)

4.2.6.2 Forecasted Climate Conditions that Enhanced Usefulness

The farmers also noted various climate conditions that they thought would enhance the usefulness of the SFs. This included temperature, rainfall, as well as the distribution and frequency of rainfall. The farmers indicated that forecasts should consider climate conditions such as temperature, wind speed, and rainfall. Various farmers noted that temperature conditions were highly important. One farmer indicated that sunshine patterns would be of greater importance to him than temperature.

“Information regarding temperature, rain, and wind should be very specific as it always changes. Wind and temperature are important.” (Caledon)

Farmers also noted the importance of the frequency and distribution of rainfall. One farmer stated that he needed to know the difference in rainfall at the beginning and end of the month. Another indicated that he needed to know how much wetter it would be, not necessarily that it would be wetter. A second farmer shared the same views regarding temperature.

“How much hotter will it be. How will it be spread into the month.” (Caledon)

The farmers emphasised the importance of information regarding rainfall. They stated that they would like to see both greater and lesser rainfall chances on the SF but noted that they preferred greater chances as they deemed it more positive. One farmer noted that the current SFs did not indicate when in the month the rain will fall. He stated that future SFs should include such information. All the farmers noted that the distribution and spread of rainfall across the time period was highly important. One further stated that he did not trust the results because they did not indicate when the rain falls in the month.

“The distribution of rainfall is just as important as quantity.” (Moorreesburg)

4.2.6.3 Information regarding Extreme Conditions

Information regarding extreme conditions were highly important for farmers as they often destroyed crop harvests and could lead to other issues. The farmers indicated that they would need information regarding excessive rainfall, which they defined as rainfall over 40mm at a particular time. One farmer stated that the likelihood of extreme events was more decision-relevant.

The farmers noted that while they often placed emphasis on rainfall, they needed information on other climate conditions as well. Information on extreme conditions such as dry spells, humidity, and temperature were considered highly useful. One farmer noted that he would like to see information pertaining to humidity and frost particularly between October and November. Another farmer noted that sunshine patterns and extreme heat were of importance. The farmers also noted that conditions that were too wet were also highly problematic for crops and therefore such information was needed in the SFs. Another farmer further noted the importance of wind conditions.

“Need entire climate, not only rain. Especially, heat and wind.” (Moorreesburg)

4.2.6.4 Localisation of SFs

The farmers indicated that the localisation and specification of information was highly useful. One farmer indicated that he wanted the forecasted information to be connected to what may happen on his specific farm. He indicated that averages for the region were too large as his farm was different to the entire Caledon region. Another farmer inquired if he would be able to zoom into his specific farm.

“Can be useful if your farm is in the optimal location from the weather forecast.”

(Moorreesbrug)

4.2.6.5 Historical SF Information

Various farmers indicated that having a history of the forecasted information would enhance the usefulness of the information. One farmer indicated that he needed historical data in order to decide. Another inquired about the effects that climate change had on historical data. A third farmer added that having a curve trend graph shows how things had changed historically and he felt that such information was important to know. The farmers stated that they would like to review previous SFs in order to assess for themselves if the information was sufficiently reliable to use.

“What is the history of the forecast? We want to follow historical numbers.” (Caledon)

4.2.7 Factors that Reduced the Usefulness of the SFs

The farmers noted various aspects of the SF and their circumstances when they perceived the information as being less useful. One farmer indicated that the forecasting statistic would not change his decisions or farming practices. Another noted that it was not that useful as farmers cannot not plant, they have to plant regardless of the weather or climate. He added that if the forecast indicated that it would be drier, he would plant and hope the SF was incorrect.

“Seasonal forecasts are helpful but [it] has no effect on fundamental farming decisions, farmers will still plant at the same time.” (Moorreesburg)

One farmer indicated that he found the information to be more interesting than valuable. This was echoed by another farmer who also stated that they were more interesting than useful. A third farmer stated that the SFs were merely another tool in their box and would just be another single aspect of their decision-making practice.

“We are not going to do any major changes based on this. This is just statistical. There is no general value to this.” (Moorreesburg)

4.2.8 Factors that Enhanced Farmers Trust in SFs

This particular theme consisted of the different aspects of SF information that would enhance farmers' trust in SFs and included experience, explanations, sources of information, and various other factors. When examining the different factors that enhanced the farmers' trust, various farmers indicated that their experiences, both past and present, with the SF would determine their levels of trust. One farmer stated that if it worked the first time, he would perceive the SF as being more reliable and this would enhance his trust.

“Reliability will be proven through experience.” (Moorreesburg)

An explanation regarding the origins and makeup of the SF information was another aspect that impacted on their levels of trust. All the farmers were unsure regarding where the information came from and felt like it was a gamble. The farmers indicated that explanations provided confidence and they were therefore less inclined to trust the SF because it lacked an explanation. One farmer indicated that the scientists needed to explain to them how the prediction was arrived at. One stated that the scientists should tell him why they were forecasting that particular information. Another wanted to know the source of the signal of the forecast. One farmer stated that the statistics sounded less reliable in the absence of mechanistic

explanations. Another stated that there was no way for him to determine if the scientists knew what they were speaking about. There was no way for him to know if the scientists had the requisite knowledge needed to make such predictions.

“What is happening with the sea temperature and high/low pressure. I need to understand more science of the forecast.” (Moorreesburg)

“Information regarding the forecasting approach that is more understandable would enhance trust.” (Caledon)

One farmer inquired about how the SF figures were arrived at and wanted to know if they had been accurate in the past. He stated that his trust in the SF would be determined by where the information came from and if it was developed locally and was specific to South Africa. Another farmer inquired about the type of weather and climate information that had been considered prior to developing the SF. One farmer was interested in knowing about the long-term trends and fluctuations as well as how these influenced the SF. Ultimately, the farmers were interested in knowing more about the source of information.

“Where does this data come from? Who is the source? How must I trust this?” (Caledon)

The farmers also provided specific percentages and probabilities of the SF that would enhance their trust. One farmer stated that a two out of five probability of a correct SF was not good enough to trust. This was echoed by the majority of farmers. They then indicated that they were more inclined to a three out of five-probability forecast or a forecast that indicated more than a fifty percent chance of being correct in the past.

4.2.9 Factors that Enhanced Farmers Understanding of SFs

This theme included various different ideas put forth by the farmers that would enhance their understanding of the SFs, by reducing the complexity of the SF to ultimately enhance their understanding. This included training, formatting, and presentation of SF information and the simplification of SFs.

One farmer proposed training as a way of enhancing his level of understanding. He stated that he had concerns regarding if and how he would need to learn to interpret the information. Another echoed this and declared that he would also need to learn how to use the SF so that he could explain it to his family. He stated that he was young and would therefore take on the responsibility of learning how to interpret the forecast so that he could explain it to his father and grandfather who also made farming decisions on their farm.

“I need to learn how to use the forecast in my family.” (Caledon)

The farmers noted various presentation formats that enhanced their understanding and also provided insight on how to ease their understanding. One farmer indicated that he would prefer the information in point form, because shorter was better for him. The majority of farmers agreed that percentages and millimetres were more intuitive and easier to understand.

“We liked the millimetres and percentages format.” (Moorreesburg)

The farmers unanimously agreed that the presentation of information needed to be streamlined. They indicated that it was important to see and interpret the information quickly and they therefore wanted quick numbers with extra information if they wanted to read more.

4.2.10 Factors that Reduced Farmers Understanding of the SFs.

This theme encompassed the aspects of SF information that reduced farmers’ understanding. This was related to the presentation of information and the various other aspects that resulted in a lack of understanding. Certain farmers indicated that they did not like a narrative or story format as reading the information was too time consuming. They did not want to have to sit and read all the information. One farmer indicated that if he had time, he would do it, but he often does not have the time. Another farmer indicated that it is important to interpret the information quickly. A third farmer indicated that the narrative format was too complex. He stated that he gets confused reading the information and that it should be made easier.

The majority of farmers indicated that there was too much information presented at once. They preferred formats that showed less dense but accurate information. The farmers also did not appreciate the map formatting as they felt it was difficult to interpret. One farmer indicated that it was difficult to differentiate between the colours on the map. Additionally, the farmers noted various difficulties in understanding the information. One farmer indicated that the skill statement was too difficult to understand. Another indicated that the formatting should be more user friendly and should show greater variability.

“Less is more.” (Moorreesburg)

4.2.11 Resources Available to Farmers

The theme, resources available to farmers’, examines the resources that farmers utilised to cope with climate uncertainty before the adoption and implementation of SFs. This included hope and indigenous knowledge.

4.2.11.1 Hope

Hope emerged as a prominent theme within the analysis. The farmers indicated that they often just planted and hoped that it would rain. They also stated that they may ignore bad news from an SF and seek out SFs that gave good news.

4.2.11.2 Indigenous Knowledge

In terms of determining climate conditions prior to the adoption of forecasts, various farmers noted that they used indigenous knowledge and knowledge of their areas in order to make climate predictions. One farmer indicated that if there was more humidity in December, they would have a better winter planting season. Another farmer indicated that the blooming of March lilies were a sign that summer was coming to an end. He added that March lilies blooming in March indicates that the upcoming season will have good rain. This is because these flowers only bloom if it rains during the month of March.

Chapter 5

Discussion

This chapter will utilise the literature and results as discussed in Chapters 2 and 4 respectively. The chapter will incorporate the fourth research question, the alignment of perceptions between the two groups of farmers, into the initial three research questions. Therefore, the similarities and differences between the two groups will be discussed in relation to their perceptions of trust, ease of use, and usefulness. The results will also be discussed in relation to previous studies conducted within the field. Thereafter the theoretical and practical implications will be assessed which will be followed by the limitations of study. Lastly, the directions for future research will be explored.

The TAM-Trust framework is a highly valuable theoretical model that has been implemented across various different fields and disciplines (McCloskey, 2006). The framework recognised the importance of trust in all relations, including those between humans and technology. This is particularly important in situations that involve uncertainty and high-risk outcomes such as decision making within the agricultural sector. Climate variability has made the agricultural sector particularly vulnerable to food insecurity and reduced production leading to reduced income. Furthermore, shifting climate patterns have exacerbated the challenges associated with the execution and planning of agricultural tasks. As a result, it is imperative that farmers are made aware of the risks associated with climate change as well as the various adaptation strategies available to them in order to mitigate the associated risks. One such strategy is long-term planning through the implementation and use of seasonal climate predictions. There has been rising wariness surrounding the adoption and implementation of such forecasting information among farmers across Southern Africa (Winsemius et al., 2014). This necessitates studies that examine farmers' perceptions of such information.

5.1 Perceived Ease of Use

What were, Eastern Cape and Western Cape, farmers and agricultural experts' perceptions regarding the perceived ease of use (understandability) of the SF information (research question one)? In relation to the first research question, farmers provided various comments regarding the understandability of the SFs. Both groups of farmers noted various factors of the SF information that reduced their understanding. Farmers in both the EC and the WC stated that the presentation format of the information reduced their understanding. Their preference of presentation however differed; EC farmers did not appreciate the picture format as they

perceived it as difficult to interpret. On the contrary, WC farmers did not appreciate the narrative format as they felt it was too time consuming to read the information. While both groups identified different presentation preferences, they did unanimously agree that the information should be more user friendly. Ultimately, farmers wanted SFs to be presented in a way that was easy to understand, easy to use, and provided valuable information. As it stands, SFs were presented to farmers using probabilities, odds ratios, and narrative explanations. These presentations utilized large amounts of scientific jargon which may be deemed difficult to understand if an individual does not possess a university qualification or have background knowledge in the field. Therefore, by presenting SFs in a manner that is easier to understand, farmers would be more likely to utilise them. This aligns with the findings of Jean et al. (2022) who further indicated that the easier an entity is to use, the more likely an individual is to use it. If farmers do not understand a forecast, they are more likely to use it incorrectly or not at all (Feleke, 2015). This is because SFs may impose some level of cognitive constraints, the restrictions imposed by the limited nature of human cognitive architecture and information processing abilities, on farmers (Feleke, 2015).

The aforementioned finding indicates two possible causes of action; scientists could develop more user-friendly SF presentations or as an alternate approach, scientists could enhance the cognitive capacity of farmers through education (teaching farmers' what the information means and how to interpret it). Both of these courses of action were mentioned by farmers as a way of enhancing their understanding of the SFs.

As mentioned previously, farmers indicated a need for a more user-friendly presentation of SF information. This is because jargon dense forecasts can be seen as daunting for an individual who does not possess a university degree within the field (Magnusson et al., 2019; Wilk et al., 2017). Eradicating such jargon from the forecasts may make it easier for farmers to understand, particularly for farmers with no formal education in the field as is the case for -both EC and WC farm groups. Ebhuoma (2020) highlights the importance of easily understandable forecasts using an example of the flood disaster in Mozambique. Despite the accurate weather forecast, communicating information regarding the flood in a manner that could be easily understood by the farmers proved to be a difficult task and resulted in devastating consequences for individuals that did not evacuate (Museumwa et al., 2010; Akerlof et al., 2012). This highlights that farmers' abilities to effectively interpret and comprehend forecasts continues to be a limiting factor in the adoption of SFs (as seen in the results). Mao et al. (2021) noted that the various challenges associated with perceived ease of use may be overcome through the

identification of the farmers' demands and by developing context specific SF formats. One way that this could be carried out would be through reducing difficult terminologies and translating complex narratives into local ideals.

The farmers noted specific preferences regarding the presentation of SFs that enhanced their understanding. Farmers in the EC preferred an oral presentation of information and also stated that a narrative format would be easier to understand. The narrative format was likened to a story which enhanced their understanding. By utilizing a story-like or narrative format, the perceived understandability of the SF would be enhanced as the EC farmers were familiar with this type of presentation. This is related to the idea that farmers did not possess tertiary education qualifications and would therefore be more comfortable using narrative formats as it provides more of an explanation. Contrary to this, WC farmers found the narrative format too time consuming to read and too complex to understand. This raises challenges regarding the most effective presentation of SFs. Scientists, therefore, will need to develop a presentation format that incorporates both aspects. It is suggested that scientists eradicate climate jargon from the SFs, present SFs using less dense information, and preferably utilise bullet-points. Simplifying the presentation of an SF will circumvent the cognitive constraints placed on farmers. This would aid in reducing the vulnerability of farmers and uncertainty of SFs, thereby positively shifting farmers perceptions regarding ease of use.

Secondly, both farm groups (EC and WC) also indicated that learning how to interpret SF information would be highly useful and that training initiatives would enhance their understanding of SFs. Through training farmers on how to interpret and understand SFs, the mental models of farmers would be developed, ultimately enhancing their familiarity with the concept. Developing farmers mental models of the SF through workshops and other training initiatives would be highly beneficial as it would allow farmers to better understand how SFs work. The aforementioned findings were shared by Kuonen et al. (2019) who noted that farmers had difficulty understanding weather forecasts due to the probabilistic presentations of 'above normal', 'normal', and 'below normal'. This presented a significant challenge because the formal probability formats had not previously been mapped into the mental models of farmers (Kuonen et al., 2019). The education levels of small-hold farmers in Africa are low (Musemwa et al., 2010). This, therefore, creates challenges in relation to the adoption of new technologies as they often have not been previously exposed to such innovations. As a result, they would not have had the chance to develop effective mental models of advanced technologies. A mental model may be defined as a mechanism with which individuals create

explanations of system functioning, descriptions of system form and purpose, and predictions regarding the future of system states (Lim & Klein, 2006). They are essentially frameworks of knowledge that allow humans to explain, describe, and predict behaviour. Ultimately it reflects an individual's perceptions of reality. As it stands, the design of the SFs currently does not match the mental models of farmers. It is therefore imperative that farmers are provided with the necessary information and knowledge on how to use and implement such technologies. Training initiatives could facilitate the development of skills and knowledge needed to understand and effectively interpret SFs. This will ultimately enhance the ease of use and the perceived understandability of the SFs.

The implementation of training initiatives would guide farmers' perceptions of SFs and would encourage them to use it in their decision making. This is linked to farmers' perceptions of trust and their related knowledge of SFs (mentioned above). Through developing farmers' mental models of SFs, scientists would be enhancing their understanding of the SFs which may lead to enhanced trust, ultimately leading to adoption. This is substantiated by findings from Ouédraogo et al. (2019) where training programs accelerated adoption amongst local farmers in Mali. Ouédraogo et al. (2019) indicated that farm workshops were key factors that improved farmers' understanding of SFs and further allowed farmers to make more informed decisions in relation to their farming practices. Such efforts enhanced the legitimacy and credibility of the SFs for farmers (Cliffe et al., 2016; Patt et al., 2005). This is further substantiated by a study conducted in Zimbabwe, where farmers that participated in SF training workshops were five times more likely to implement SFs in their decision-making practices (Patt et al., 2005). This is because training was seen as a form of a structural assurance belief or a safety net regarding the implementation of a new technology. By understanding the information presented in the forecasts, farmers will feel more assured with their decision to implement the SFs into their farming practices.

The implementation of training initiatives, however, does have various drawbacks. Firstly, educating farmers regarding SFs may be highly challenging due to the different levels of formal education between farmers. Secondly, farmers might require continuous guidance on how to implement and understand SFs, this is problematic as initiating training workshops requires logistical planning and is highly time-consuming for all parties involved. Lastly, each farm group had different perceptions regarding the forms of training initiatives. This may be highly problematic when developing a uniform training initiative or workshop. While WC farmers

opted for learning how to interpret the information themselves, EC farmers put forth a differing perspective and suggested that extension officers or lead farmers should be trained on how to interpret the information and they could then present it to the farmers (this may be linked to the reduced levels of education mentioned previously).

Having assessed all the benefits and drawbacks, it seems likely that the best course of action would be to develop training initiatives for selected individuals or officers (i.e., extension officers in the EC) from agricultural organisations such as Overberg Agri (in the WC) and GrainSA (in the EC). Such individuals should be trained on the interpretation and implementation of SFs in agricultural decision-making and can then develop their own agricultural workshops to relay such information to farmers. This will allow the officers to structure the workshops according to the needs and preferences of local farmers. This, in conjunction with the simplified presentations of SF information will enhance farmers' understanding of SFs ultimately leading to adoption.

5.2 Perceived Usefulness

What were, the Eastern Cape and Western Cape farmers' perceptions regarding the perceived usefulness of the SFs (research question two)? Popoola et al. (2020) assert that the more useful an entity is perceived to be, the more likely an individual is to use it. The findings of this study indicated that farmers from both groups did not have completely positive perceptions regarding the usefulness of SFs. Both farmer groups noted that the accessibility of SFs hindered their level of perceived usefulness. Furthermore, EC farmers did not have access to SFs and noted that their local resources (smart phones, cellphone reception and internet access) usually did not allow for it. They were, however, interested in knowing how they could enhance their levels of accessibility. Accessibility is highly important when considering the usefulness of an entity. Without adequate access to an entity, the entity becomes inherently useless. Farmers in both the EC and WC cited inaccessibility as a contributing factor to their perceptions regarding the usefulness of SFs. This lack of access may be attributed to a lack of resources within these communities, a lack of awareness regarding the availability of such information as well as a lack of structural developments that could facilitate access to such resources (i.e., electricity and internet access). Muita et al. (2021) note that the adoption of new technologies and other forecast information in Eastern Kenya was influenced by farmers' levels of access to the information. They further noted that such information would be highly useful in making effective and timely decisions (Muita et al., 2021).

In the EC and WC, the lack of access to climate information was a critical factor that reduced farmers' resilience to climate change. The current lack of access reduces their levels of awareness ultimately reducing their adaptive capacities. This is because farmers' ability to effectively cope with such changes is highly dependent on their knowledge (as mentioned previously) as well as their accessibility to such information. Enhanced and adequate access to climate information increases awareness ultimately enhancing farmers' adaptive capacity (Wilk et al., 2017).

As it stands, national meteorological organisations are usually responsible for the distribution of climate information across the country. Hassan and Nhemachena (2008), however, note that various countries in Africa have yet to develop effective dissemination strategies (Hassan & Nhemachena, 2008). This has resulted in low levels of awareness and adoption of SFs locally (within local communities) and nationally (within South Africa). It is therefore imperative that the issue of accessibility is addressed by climate scientists.

One way that the issue of accessibility may be addressed is through the effective distribution and dissemination of SFs. Both farm groups provided insight regarding their preferred methods of dissemination. Western Cape farmers preferred more technologically advanced methods and cited the use of mobile phone Apps and websites. Contrary to this, farmers in the EC preferred more administrative channels of distribution citing school and local clinic notice boards as well as through extension officers. Television, radio, and distribution using WhatsApp messages were also mentioned as viable options. They did, however, note that some farmers did not have access to the internet or social media. The effective dissemination of SFs is highly important in enhancing the implementation and usefulness of SFs. Seasonal Forecasts are of no benefit to farmers unless farmers have access to such information. There, however, are differences in farmers preferences regarding the dissemination channels. Prior to developing effective dissemination strategies, facilitators need to take into consideration the different practices of farmers and their access to resources when deciding on the most effective ways to disseminate SFs. This will ensure that there is no misalignment regarding the distribution of valuable information. It is evident from the aforementioned results that effective locally specific dissemination strategies need to be developed in order to enhance the responsiveness of agricultural communities. The appropriate dissemination of climate information is a critical factor in the usefulness and effective adaptation of SFs. Nkeme and Ndaeyo (2013) highlight that sufficient climate information ultimately equips agricultural experts and farmers in acclimatizing to climate change.

In the EC, farmers preferred information being posted on the notice boards of schools and clinics or even through extension officers. This may be because these communities do not have the required infrastructure needed (i.e., electricity and internet connection) for more technologically advanced dissemination methods such as Apps or websites. This highlights the importance of using appropriate communication methods for vulnerable communities when trying to manage climate risks. Therefore, the methods of dissemination used will need to be cognisant of this.

Cooper et al. (2008) has conducted various studies in Sub-Saharan Africa and has concluded that the aforementioned dissemination issue may be addressed through the use of traditional mechanisms such as radio and television. This suggestion has been echoed by certain farmers in the EC who mentioned radio or television distribution and even using WhatsApp messages as a way of disseminating such information. Mburu et al. (2015), who conducted a study in Kenya, asserts that such modes of dissemination are important factors in adoption and generally trigger effective action among small-hold farmers. This is because television and radio are vital media for conveying such information to rural households within developing nations and are related to the fact that rural households in South Africa seldom have access to the internet and adequate cellular phone reception to access SFs electronically.

While dissemination using school and clinic notice boards as well as radio and television dissemination may be useful for providing access to farmers, they are not necessarily the most effective strategy. Farmers usually have highly intricate agricultural routines that require effective time management and planning, and they are also generally busy throughout the day. If one were to implement the afore mentioned dissemination strategies, farmers would need to take time out of their daily routines to physically visit the schools or clinics to view the SFs or even schedule a specific time in their day to watch the SFs on TV or listen to it on the radio. This, ultimately, takes them away from their important daily farming routines. While WhatsApp may not be the best option due to their lack of internet access, text messaging services seem like the most cost and time effective strategy. Receiving text messages will not disrupt their daily routines and will not be impacted by their lack of internet access.

In relation to dissemination in the WC, the results contrasted with the EC, as these farmers preferred more technologically advanced methods using Apps or websites. Western Cape farmers generally lived in more developed communities with enhanced resources when compared to the EC. Furthermore, the WC commercial farmers generally have capital and

resources to better develop their farms. Therefore, an App or website would be highly effective in distributing SF information to farmers. Additionally, farmers are free to access the information whenever they may need it as it does not impose particular time constraints (that are present in radio and television broadcasts). This is highly beneficial to farmers who already have a complex web of daily activities. The acceptance of Apps and mobile phones has significantly influenced farmers access to climate information through short messages (Baumüller, 2016). This improvement in their access has enhanced the decision-making of farmers (Baumüller, 2016).

In relation to the dissemination of SFs, the importance of presenting such information in local languages is highly important in enhancing the usefulness of the SFs and should therefore not be overlooked. Both farmer groups felt that the information should be presented in common local languages in order to enhance its usefulness. As mentioned previously, farmers found it difficult to understand SF information due to its complex presentation. Adding to this, the information was presented in English which is not the mother tongue of either farm group. This further reduced farmers' levels of understanding. In the EC, farmers' home language was predominantly isiXhosa and in the WC farmers' home language was predominantly Afrikaans. The complex presentation of SF information coupled with the fact that it was presented in a second language (English) reduced farmers' understanding of the SFs. Huq et al. (2004) noted that farmers mentioned various instances when climate information was not broadcast in their mother tongue, such information was not understandable and was therefore deemed as unvaluable to them. This highlights that farmers in various study areas wished to receive disseminated information in their local languages. Ageyo and Muchunku (2020) noted that enhanced access to climate information is highly useful for adaptation to climate change. However, such information was often deemed ineffective if it was distributed in languages that users were not fluent in, as was the case with both farm groups. It is therefore important that before SF information is disseminated, it should be translated into local languages in order to enhance its usefulness and encourage its uptake. This can be achieved with the help of agricultural organisations such as Overberg-Agri or GrainSA. Information should be translated into local languages before it is texted to farmers or uploaded on a website.

Accuracy is considered an important factor when determining the perceived usefulness of SFs. Both farmer groups highlighted the importance of accuracy of the SFs and indicated that enhanced accuracy would support the usefulness of the SF and further increase their trust in the forecast. Certain farmers indicated that they were more inclined to believe in weather as it

demonstrated more accurate predictions. Ultimately, farmers believed that the usefulness of the forecast would be determined by its accuracy. It is evident from the results that the accuracy and reliability of an SF is considered an important factor to farmers as it was raised a number of times; first in relation to trust and thereafter in relation to perceived usefulness. This is understandable as preparing their farms according to a particular prediction would consume a large amount of time, resources, and capital. Should the prediction not occur farmers would waste the time, resources, and capital that was invested into preparing for that prediction. The aforementioned results indicate that farmers believe SFs to be gospel predictions of future climate events. This is not necessarily true; it is therefore important that farmers understand and are made aware of the actual nature and purpose of SFs. This aligns with the findings of Vaughan et al. (2019) who asserted that farmers in Sub-Saharan Africa have been sceptical of climate scientists' ability to accurately predict future climate events. While the implementation of SFs was highly effective in mitigating climate risks in crop farming through effective preparation and decision making, it is important that farmers understand the true accuracy and reliability limitations of SFs.

There are physical limitations to the predictability of the atmosphere, therefore, accurate climate forecasts are not possible beyond two weeks (Millner & Washington, 2011). It is, therefore, important that farmers are made aware of the fact that making accurate predictions during all seasons in all regions is not possible. This is because such predictions are dependent on a region's connection to predictable patterns (i.e., El Niño Southern Oscillation) (Millner & Washington, 2011). If a particular region does not have a strong connection to a predictable driver, it is likely that accurate forecasting will not be possible (Millner & Washington, 2011). As a result, SFs cannot provide detailed events as seen in weather forecasts under all conditions and in every location, because the further into the future you go, the less accurate an SF becomes. Rather, SFs provide an indication of likely average conditions over a number of months (is a season more likely to be wetter than a normal season).

In relation to the overall usefulness of SFs, a few farmers in both groups stated that they did not perceive the SFs as being useful. They indicated that the SFs would not change their decisions regarding the best possible time to plant and they would continue to plant when they usually did. This was linked to the idea that SFs could not be useful as the climate continues to change. They further linked this to the inaccuracy and uncertainty of the SFs. While farmers noted the importance of accurate forecasts, implementing an SF with some degree of certainty would arguably be more beneficial than not implementing one at all. Seasonal Forecasts

provide farmers with indications of the potential average conditions of a season. Therefore, it would be beneficial for farmers to plant during a season that has some prediction of wetter conditions as opposed to planting without having any indication at all. This is because planting during a season or month that has a slight indication of rain would enhance their chances of producing an effective crop yield.

While the farmers noted various aspects of the SFs that reduced their perceived usefulness, namely, a lack of accessibility, inadequate dissemination strategies and a lack of accuracy of SFs, they did also note various instances when SFs would be highly useful to them as well as ways that scientists could enhance the usefulness of the SFs. This was linked to preparation, effective timeframes of the SFs, preferred climate conditions, and decision-making strategies.

Both groups deemed SFs as useful in relation to preparation. However, their preparation preferences differed. Eastern Cape farmers noted that SFs would be beneficial for animal preparation, crop selection as well as field and soil preparation, planting dates, insurance, and financial planning. Western Cape farmers on the other hand were likely to use it for marketing and advanced sales guarantees as well as fertilization planning. The differences in the socio-economic status of EC and WC farmers is made clear here. Preparation for EC farmers consisted primarily of physical aspects such as preparing their fields, soil, and planting dates. They did mention insurance and other financial preparation issues, but precedence was not placed on these. Western Cape farmers on the other hand noted preparation that was linked to financial circumstances such as sales guarantees and marketing. Such differences are a result of their different farming dynamics and socio-economic conditions; the EC consisted of small-hold subsistence farmers whose agriculture output was mostly used for self-consumption. They were therefore not interested in generating profits and were more concerned with growing food to feed their families. On the contrary, the WC consisted of commercial farmers who sold their agricultural outputs to generate revenue, therefore their preparation preferences aligned with more financial aspects.

Having assessed the differences in both groups, it is worthwhile to note that both groups were interested (albeit at different levels) in field, soil preparation and fertilizer preparation (the WC slightly less than the EC). This is because implementing preparation strategies based on SFs is highly important in enhancing the adaptive capabilities of farmers and in improving their crop yields. Such information supports timely decision making which may reduce climate risks and enhance farm productivity.

An-Vo et al. (2021) noted that adjusting sowing dates is an important adaptive strategy that reduces the impacts of climate variability. By optimising the sowing times, farmers were able to grow crops within a timeframe of suitable climate conditions (An-Vo et al., 2021). Seasonal climate conditions are important drivers of crop production in rain-fed farming systems as found in South Africa (An-Vo et al., 2021). The start of the crop planting season is determined by land preparation, this ultimately impacts the timing of crop harvests. In order to ensure effective harvest outputs, land preparation should be followed by rainfall as soil moisture is imperative for the establishment of early crops (Roudier et al., 2016). Therefore, SFs will benefit farmers by indicating a sowing window that is characterised by minimal risks. They may also further aid in developing suitable strategies to deal with hail, flood, and drought risks through the use of climate indicators.

While farmers mentioned that SFs were useful for preparation, they further provided ways of enhancing the usefulness of SFs. Both farm groups indicated that the time frame of an SF was highly important, however, they had different preferences regarding the most effective time frame. Eastern Cape farmers preferred the forecast three months in advance. This differed from WC farmers who preferred longer term forecasting from a few months up to a year in advanced. Such results are highly understandable as farmers need adequate time to prepare themselves for the upcoming planting season. Timing is a highly important factor within agriculture as effective timing allows farmers to determine when and how they can plan for the season ahead. This is because farmers need a large enough time frame to develop and implement their farm strategies.

Ingram et al. (2002) noted similar results in his study on climate forecasts in Burkina Faso, where farmers noted that sufficient lead time was highly important as it allowed them to make irrevocable decisions. Ash et al. (2007) states that a planting period, generally between 30-90 days indicated by climate zones and rainfall patterns, is the most crucial frame of a cropping season. Therefore, early warnings of climate conditions regarding whether a season may be wetter or drier than normal provides them with more time to prepare (Ash et al., 2007).

Seasonal Forecasts provide probabilistic indications of future average conditions and are generally produced as an average over a three-month basis. Therefore, farmers in the EC can receive SF information three months in advance all year round. However, this is not the case for WC farmers who preferred forecasts 6 months to a year in advance. The El Niño–Southern Oscillation can only be accurately predicted 6 months prior to an event occurring, therefore it

is not possible to provide accurate SF predictions a year in advance (Ramírez & Briones, 2017).

A second way that farmers thought the usefulness of SFs could be enhanced was through the provisions of different types of climate information. Farmers (both WC and EC) highlighted the different types of climate information that they would like to get from an SF. The farmers agreed that SFs should provide information regarding temperature, wind speed, rainfall patterns, as well as the frequency and distribution of these conditions. Farmers further noted the importance of providing information regarding extreme conditions such as dry spells, humidity levels, hail, and floods. Eastern Cape farmers added to this and indicated that conditions regarding frost and hail were also important. Various studies indicate that information on extreme climate events and rainfall patterns influences the adoption and use of SFs by farmers due to the devastating impacts that such conditions can have on the sector (Jillo & Koske, 2014). This is because agriculture in South Africa is highly reliant on rain as most crops are rainfed and tremendously vulnerable to extreme climates. Therefore, the availability of such information is crucial in supporting the effective yield of crops within the country.

Current high frequencies of climatic inconsistencies have subjected the Earth to droughts, storms, floods, and other climate change threats that have immense impacts on agricultural yields (Hartmann et al., 2002). This poses severe consequences for farmers due to the reduced length of the growing season, fire outbreaks, and a loss of arable land. Furthermore, this impacts agricultural production processes related to the absorption of nutrients, evaporation, excessive or shortage of soil moisture, and damages to the crop yield potential. As an example, wet conditions coupled with high temperatures creates a conducive environment for the growth and breeding of pathogenic organisms that increase the incidence of crop diseases (Hartmann et al., 2002). In a study conducted by Kalungu et al. (2013) farmers cited increased floods, temperatures, and droughts as a leading cause of declining crop production. Farmers claimed that they needed such information in order to decide which agricultural practices they should follow in order to initiate new tillage methods or early planting (Kalungu et al. 2013). Therefore, farmers need SF information of extreme climate conditions such as droughts or floods in order to enhance their resilience to climate shocks.

Furthermore, countries within Southern Africa have very limited surface water irrigation, therefore patterns of rainfall are extremely important to ensure the effective growth of rainfed agriculture (Baaru & Gachene, 2016). The planting season within the EC and WC takes place

irrespective of rainfall, as seeds are able to remain in the soil with a fertilizer pallet (nearby) until rainfall. However, only after soaking rainfalls will the seeds germinate and sprout (approximately a week later). It is important to note however, that the soil needs to remain wet for an entire week after the emergence of the sprout or the plant will wilt and die as the soil dries out. In such an instance, farmers will have to abandon the crops and replant. Therefore, it is inherently important that farmers receive information regarding the frequency and distribution of rainfall patterns.

In addition to the different types of climate conditions, farmers highlighted the importance of the aforementioned information being localised and specific. Farmers noted that climate conditions differ within different locations of a region, therefore having general climate information about a particular region is not necessarily helpful as climate conditions may be different between each farm location. This aligns with the findings of Patt et al. (2007) who reported that farmers preferred forecasts that were downscaled and locally significant. Therefore, farmers assert that in order to enhance the usefulness of SFs, scientists need to develop localised and specific SFs that they could use to determine the climate conditions over their farms. While idealistically this may sound like the perfect solution, as it stands SFs have not yet been developed with such small-scale (i.e., at a farm level) spatial details. SFs are currently being provided at a regional scale and indicate if a particular broader area will be above or below normal conditions. This is because South Africa does not yet have the infrastructure needed to develop location specific SFs. Furthermore, the models that have been developed are not yet sophisticated enough and El Niño-Southern Oscillation signals might not be strong enough to provide accurate predictions. To provide location specific projections, weather tools and other climate infrastructure will need to be developed in specific locations in order to account for the variability across smaller regions. Climate scientists would need more weather stations to collect data to inform the climate models for a smaller spatial resolution. This would be highly costly and extremely time consuming. Extensive investments like this are not feasible in instances where there is a possibility that SFs may not even be adopted by farmers, in such instances weather forecasts may be used instead of SFs.

Farmers linked the usefulness of SFs to decision making and further indicated how such information would affect their decision making. Farmers in the EC noted that SFs would be highly beneficial in planning ahead and dealing with risk aversion. Implementing SFs into their decision-making practices would minimise their losses as they would be better able to prepare, ultimately minimising the risks associated with climate uncertainty. Western Cape farmers

echoed similar sentiments but added that overnight decisions made using SFs will have long term consequences on their agricultural outputs. The adoption and implementation of SFs was aimed at aiding farmers in their agricultural decision making to enhance their resilience to climate change. By reviewing the SF information, farmers will gain a better indication of the climate conditions for the upcoming season. They can use this information to determine the most effective strategies to use under unfavourable conditions and may even aid them in developing management strategies and conservation techniques. A pilot study conducted in Zimbabwe highlighted gains from the use and implementation of SFs (Patt et al., 2005). The results revealed that farmers who made decisions taking SFs into consideration had greater crop yields at the end of the planting season (Patt et al., 2005). Such informed decisions may result in improved livelihood outcomes and improved socio-economic conditions of farmers (Challinor, 2009; Klopper et al., 2006). This could also aid farmers in managing disaster risks (Kumar et al., 2021).

Lastly, both farm groups cited hope as their coping mechanism for dealing with climate uncertainty. The farmers indicated that they hoped for rain regardless of climate conditions or any other factors. Farmers stated that they remained hopeful and would continue cultivating areas that would usually be deemed suitable under their desired climate conditions (usually rain). This raises concern regarding the implementation of hope as a coping strategy. Hope is defined as the desire and anticipation of something (Eriksen et al., 2005). It is a positive state of mind based on the expectation of a positive outcome (Eriksen et al., 2005). This is particularly interesting, while farmers had negative perceptions of SFs due to uncertainty, they were willing to hold a positive perception regarding the likelihood of their preferred climate conditions. This raises the question of whether, hope was a better coping mechanism compared to using SFs. Considering this, farmers may consider developing positive perceptions regarding SFs (much like hope) as this will allow them to capitalise on the opportunities provided to them. The information provided through SFs may be used in conjunction with hope to enhance their resilience and agricultural outputs.

5.3 Perceptions of Trust

How likely were Eastern Cape and Western Cape farmers and agricultural experts to trust the information provided by SFs (research question 3)? The results presented above provide detailed insight regarding farmers' perceptions of trust regarding the SFs in both the EC and the WC. Trust is crucial in all interactions, particularly those containing an element of uncertainty or risk. Due to the nature of uncertainty of the climate, trust is inherently important

in SFs. The results of both (EC and WC) farmer groups indicate that farmers were unlikely to trust SFs due to their high levels of uncertainty, a lack of reliability, a lack of accuracy, and reduced trust in scientific knowledge. Farmers' lack of trust is understandable as there are large risks associated with implementing a new strategy. Farmers rely on their crop outputs to feed their families and generate revenue, therefore, there are various risks at stake if a prediction does not occur. Furthermore, farmers often do not have financial resources to compensate for loss of crops due to inaccurate SFs. This aligns with the findings of Roncoli et al. (2011) who stated that farmers were not inclined to trust SFs due to their high levels of uncertainty. Similarly, McCown et al. (2012) notes that such uncertainties often reduce farmers' trust due to the high levels of risk associated with uncertainty in the agricultural sector. However, it is important to note that uncertainty and errors are inevitable in forecasting, as models are often approximations of reality because actual climate systems contain high level complexities that cannot be fully captured. Scientists use thousands of daily observations from across the world to create computer models that simulate climate systems and ultimately generate SFs (Uche et al., 2020). Different models are run using slightly different versions of the original model in order to determine the least likely and most likely outcomes regarding how the climate could change over time. This is termed ensemble forecasts and is also used when determining the skill of a forecast (Palmer et al., 2008). Such forecasts are used to determine long-term and seasonal forecasting; however, uncertainties are amplified over time and the ability to accurately depict real climate systems decreases over longer forecasts (Palmer et al., 2008). As a result, climate scientists are unable to ensure the absolute certainty of SFs. It is, therefore, imperative that climate scientists identify different and effective ways of communicating and explaining such uncertainties to farmers in ways that may enhance their trust. Farmers need to be made aware of the fact that continuous shifts in weather and climate conditions are responsible for failures in SFs. Unrealistic demands and expectations from users in relation to the accuracy and uncertainty of SFs will reduce their trust in SFs. Farmers need to be made aware of the fact that by nature of their composition, SFs cannot be 100% accurate because atmospheric circulations are highly sporadic, and we therefore cannot predict daily forecasts (or even monthly averages) months in advance.

Farmers' lack of trust in SFs is closely linked to their scepticism regarding scientific knowledge. Turnbull (1997) notes that issues regarding the public's interest and acceptance of science is a long-standing issue dating back to the early 1500's. Nicolaus Copernicus (1473–1543) and Galileo Galilei (1564–1642) lived in a period when science was separated from

everyday life and religion played a crucial role in the stratification of society (Zanatta et al., 2017). While society has progressed and scientific discoveries are no longer frowned upon, scepticism of science and scientific knowledge continues to prevail in current society (Wynne, 1992). Various researchers have argued that this is a result of the ways in which scientists have previously distanced the scientific domain from the general public (Kloppenburger Jr, 1991). Issues of public understanding of science and their perceptions of risk are closely linked to their perceptions regarding the credibility of science and their levels of trust in science (Whyte & Crease, 2010).

In South Africa, non-white individuals were previously disadvantaged and therefore did not have adequate access to suitable education or any form of scientific knowledge. As a result, most non-white individuals born before the abolishment of apartheid are sceptical of science as it is seen as a new concept that differs from their usual indigenous knowledge systems. This is a deep-seated issue that requires a change in perspective from individuals', however, scientists can aid in altering such beliefs (i.e., farmers). Scientists and researchers should communicate scientific knowledge in ways that are clearer and can be easily understood in lay terms (this will be assessed in more detail below). Furthermore, this discussion should include an explanation of SFs so that farmers are provided with an understanding regarding the ways in which uncertainty is embedded in SFs so that they are able to manage their expectations when utilizing SFs. Furthermore, by increasing the accessibility of SFs, farmers exposure to such information will be increased which will ultimately alter the perceptions of scepticism surrounding it. SFs will no longer be seen as a distant or foreign scientific concept and will ultimately be adopted by farmers.

Experience was noted as another important factor that reduced farmer's trust. Both groups of farmers noted that their levels of trust would be based on previous experiences with SFs. As mentioned above, farmers are highly sceptical of new scientific information. This is related to the idea that they have been distanced from it and have not had enough interactions with it. Such scepticism may be reduced by interacting with SFs or gaining experience when using it. The more an entity is used by an individual the more likely the entity will be viewed as normal. This is linked to situational normality beliefs (SNB) which arise as a result of a trustors belief that a situation/entity is normal and is gained through experience (Gefen et al., 2003). Furthermore, the more positive experiences farmers have with SFs the more likely they are to continue using it.

Diouf et al. (2020) shared similar findings and noted that credibility is often based on reputation. Therefore, the more positive experiences farmers have with SFs, the more likely they are to implement them into their daily farming practices. Freitag and Traunmüller (2009) further added that reputations are easy to destroy but difficult to build, therefore if farmers perceive an SF as being wrong in the past, it is unlikely that they will trust it in the future unless it has an existing track record of being right. It is therefore imperative that climate scientists provide farmers with clear understandings of how to interpret and implement the initial SFs, so that farmers are able to build positive relationships of trust with the SFs in the future. Furthermore, scientists may also provide farmers with accurate historical data so that they are able to assess the SFs and ultimately develop trust in them.

Farmers deemed the risks associated with SFs as an important factor that reduced their trust in SF information. As mentioned previously, farmers' aversion is understandable due to the risks associated with implementing SFs. EC farmers often do not have excess capital for adaptation strategies; therefore, they are generally reluctant to trust an entity if it is perceived as unreliable. Western Cape farmers on the other hand, farm larger areas of land, invest more capital and often have more individuals reliant on their crop outputs. Therefore, the financial stakes are higher for this group when compared to small-hold farmers. Due to the nature of their high stakes, they are more risk averse and are less inclined to trust SFs due to the high nature of risks associated with SF information. Most individuals within the agricultural sector are risk-averse due to the high stakes within the industry (Barham et al., 2014; Chen et al., 2019). As a result, the reduced trust associated with the uncertainty of SFs is made up of two aspects: ambiguity and risk. Ziervogel et al. (2005) notes that risk-averse individuals are therefore less likely to adopt new technologies. In instances when new technologies exhibit high levels of exposure to risk, aversion provides a dis-incentive to adopt the technology (Hagger et al., 2018). However, if the new technology aids in the reduction of risk than it is more likely to be adopted (Barham et al., 2014). For example, if the SF indicates wetter than normal conditions and farmers alter their practices to prepare for this. During planting season, the farmers realise that the SF was accurate, and they were able to avoid crop damage due to rain, they would be more likely to adopt the SF in the future. This is closely linked to personal experiences with SFs but includes aspects of risk management.

Risk management deals with managing the adverse effects of risky decisions. It is an iterative process and therefore the risks continue to be evaluated at different stages (Hobday et al., 2016). During various stages of interactions with SFs, farmers will continue to analyse the level of

risk involved. Hence, it is imperative that all associated risks are identified, and an analysis made regarding the impacts of such risks are put forth before farmers interact with SFs (Jones & Preston, 2011; Barham et al., 2014). Farmers cannot afford to risk losing their entire crop and therefore make choices in order to increase the chances of harvesting sufficient yields. Therefore, developing farmers' trust in SFs is extremely difficult, particularly due to their potential impacts on their livelihoods. As a way of implementing effective risk management and reducing the impact of risk, all risks associated with SFs should be explained to farmers (deviations from normal conditions, climate anomalies, related uncertainty) and should highlight how it may affect their field crops. While scientists are able to communicate all associated risks with farmers, it is important for farmers to note that SFs cannot be completely risk free because the initial data used to calculate an SF will never be completely accurate. Seasonal Forecasts simulate possible changes in the ocean and atmosphere over a period of time based on current conditions. However, due to the unpredictability of climate phenomenon it is not possible to make 100% accurate predictions. Therefore, SFs by nature will always contain an element of risk.

The aforementioned point highlighted the aspects of SFs that reduced farmer's trust. However, farmers also noted that their trust in SFs could be enhanced by educating them regarding the origins of SF information and if the forecasted information presented in the SF aligned with their indigenous knowledge. In relation to the disparities regarding trust perceptions between WC and EC farmers, WC farmers indicated that an explanation regarding the origins of the information would enhance their trust in the SFs. Western Cape farmers were interested in knowing how and where the SFs were derived. This aligned with the findings of Wingreen and Baglione (2005) who noted that knowledge sharing was an important aspect of relationship building and often enhanced trust between individuals. This is because sharing and imparting knowledge positively influences trust (Kipkosgei et al., 2020). This, therefore, suggests that individuals were more inclined to develop trusting relations in environments that share information. Contrary to this, withholding information is associated with a distrust loop. This finding further aligns with a second study conducted by Patt and Gwata (2002) in Zimbabwe. Patt and Gwata (2002) stated that farmers may become suspicious of SFs if they did not understand the scientific methods used when developing it. In order to enhance farmers' trust in SF, scientists should explain the process of developing the SFs to farmers. This, however, may be a difficult task as farmers might not have background knowledge on climate science. The formulation of a SF is a highly technical and complex process, therefore, explaining this

to farmers (who do not have background knowledge) may prove to be a difficult task due to the large amount of technical jargon needed to explain certain climate phenomena.

Lastly, farmers were more likely to trust the SFs if they are aligned with their indigenous knowledge and if the SF was correct more than half the time. Both farm groups noted the importance of indigenous knowledge and the impacts that it has on their levels of trust. This is closely linked to the experiences that they have had with indigenous knowledge in the past. Indigenous knowledge is defined as traditional, place-based knowledge that is rooted in local cultural ideals (Radeny et al., 2019). Such knowledge is often passed down from generation to generation through verbal history and often makes connections with surrounding environments (Wynne, 1996). Streetkerk et al. (2022) noted that trust may be impacted by the way that the SFs either contradict or support local beliefs about climate conditions. This could be based on environmental indicators or cultural norms (Streefkerk et al., 2022). Farming has been a long-standing practice across the African continent and therefore indigenous knowledge regarding the weather is a well-established concept in various communities (Šakić Trogrlić et al., 2019).

Indigenous knowledge systems have been used for generations across the continent and have proven through past experiences to be reliable (Mapfumo et al., 2016). Farmers are comfortable and knowledgeable about such beliefs and therefore do not perceive it as being high risk. Therefore, when SFs align with indigenous knowledge systems farmers are more likely to trust them and implement them in their agricultural decision making. However, if SFs aligned with indigenous knowledge, this would indicate that indigenous knowledge is accurate and reliable. As a result, there would not be a need for SFs as farmers could base their decision making on indigenous information sources. This raises concerns regarding the reliability of indigenous knowledge within the agricultural sector.

While indigenous knowledge systems continue to be relied upon by farmers across the African continent, it is important to note that such decisions do not necessarily highlight the risks involved when such knowledge predictions do not translate into action. Farmers' trust in indigenous knowledge is linked to their familiarity and experience with it, however such information is not risk-free. Therefore, as mentioned previously, wider exposure to SFs across the agricultural sector is likely to enhance farmers' familiarity with SFs which may ultimately enhance their trust in the information.

5.4 Theoretical Contributions and Practical Implications

The study has added to the body of knowledge regarding the adoption of SF technologies within the agricultural sector. Specifically, there has not been research conducted on the impacts of trust, perceived ease of use, and perceived understandability of the adoption of SFs. This study, therefore, provides a good framework and foundation for the development of other research objectives. This study also notes the importance of farmers' perceptions regarding SFs and how this may influence their decision making. Therefore, there should be some form of understanding among climate scientists and other researchers regarding the way in which they present information to farmers as this may alter their perceptions of the presented information. Furthermore, this research added to that of Mathablela (2022) as it supports the finding that perceived ease of use and perceived understandability does have an impact on the adoption of SFs. However, it also shows that farmers' levels of trust is an important factor that guides their behaviour surrounding the adoption and implementation of SFs.

A key practical implication that this study has reflected on is the importance of educating farmers regarding the development, presentation and implementation of SFs. It is critical that farmers are able to understand the information presented to them and how it can guide their daily agricultural decision making. It is also important that climate scientists take into consideration the different socio-economic and community resources of the farmers when deciding the best possible ways to disseminate and distribute SF information. Lastly, it is inherently important that climate scientists explain to farmers the nature and predictive capabilities of SFs so that farmers are able to manage their expectations regarding the accuracy and certainty of the SF information. This may be conveyed to farmers during the training workshops.

5.5 Limitations

As is the case with qualitative studies, there are certain limitations that should be considered. Firstly, the researcher's biases may affect the interpretation of farmers' responses due to the subjective nature of qualitative research. However, it is important to note that a reflexive journal was used to report and reflect on any biases that may have been present in the interpretation of the results. Secondly, qualitative studies do not allow for large participant pools due to the time-consuming nature of recording and analysing the participant's responses. This may influence the generalisability of the results as the participants of the study did not provide a full representation of the entire agricultural community. Rather, the information would be relevant to the South African context and a select group of individuals within the

field. Further research is required to develop this body of knowledge for it to be generalisable to a greater population.

The following limitations should be taken into consideration in relation to the study. Firstly, the participant pool of the study did not include all races, the demographics only included farmers that identified as Black or White. It is important to note that this was not a deliberate selection. However, the exclusion of other races (such as Coloured or Indian) may negatively impact on the generalisability of the findings. From the results it is evident that the farmers in each province highlighted different preferences, therefore, the selected locations of the study may have limited the generalisability of the results. The study focused on the EC and WC. This may limit the generalisability of the findings in relation to other provinces. Furthermore, the study did not include an equal ratio of men and women in the WC, this is another factor that may limit the generalisability across gendered identities. However, it is worthy to note that the unequal ratio of men to women in the WC may be a true reflection of the proportion of female commercial farmers in the WC. Furthermore, the study focused specifically on grain farmers. This largely excluded wine farmers, fruit and vegetable farmers as well as livestock farmers. Ultimately, this may further limit the generalisability of the findings.

The study utilized focus groups as a data collection procedure, this may have limited the quality of the responses as focus groups do not allow for in-depth responses with participants which is generally achieved with one-on-one interviews. Furthermore, this may result in group biases which may alter the true perceptions of participants.

5.6 Recommendations

There are a number of recommendations and directions which future research could use. Firstly, future studies can utilize more racial and gender inclusive samples to enhance the generalisability of the results. This could include farmers that identify as Coloured or Indian as well as female farmers within the WC. This will aid in enhancing the generalisability of the results and may also aid in understanding the differences in perceptions between diverse farm groups. Future studies may also consider conducting research in other provinces within South Africa (Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, and North West). This will provide climate scientists with an opportunity to explore the influences of decision making in other regions and further determine the differences of perceptions and preferences as well as the different factors that may influence these differences.

Additionally, it may be worthwhile to provide farmers with more information during the focus group workshops. It may be useful to understand whether additional information may positively alter farmers' perceptions of the SFs. This could include the methods used to develop the SFs as well as information regarding the accuracy and certainty of climate indicators. Furthermore, scientists could consider distributing SFs to farmers prior to the workshops so that they may try to utilize it or gain experience with it prior to conducting group sessions.

Climate scientists should consider aligning with agricultural organisations within the different provinces. This may aid in developing relationships between farmers, scientists, and these organisations. This will bridge the knowledge gap regarding SFs ultimately reducing farmers scepticism of SFs which may lead to enhanced adoption and implementation of SFs.

Researchers may also consider using a different theoretical framework that examines other factors that may influence the adoption of SFs. This will create a holistic understanding of the different contributing factors that may play a role in the adoption of SFs.

5.7 Conclusion

Significant studies have been conducted in an attempt to understand the motives that guide human behaviour and decision making. This study adds to this knowledge pool. The aim of the study was to understand the motivators and hindrances of farmers' adoption of SFs by examining their perceptions. The study conducted a psychological assessment of farmers' perceptions in relation to ease of use, usefulness, and trust. The second objective was to determine the differences in the perceptions of ease of use, usefulness, and trust between EC small-hold subsistence farmers and WC commercial farmers. Lastly, the study aimed to investigate the changes that needed to be made to SFs based on farmers' perceptions, in order to increase the perceived ease of use, usefulness, and trust of the SFs in order to enhance adoption.

In relation to perceived ease of use, the findings indicated that farmers perceived the presentations of SFs as difficult to interpret and therefore were not inclined to implement SFs into their daily routines. The farmers in both provinces also had different preferences regarding the presentation of information with EC farmers preferring a narrative presentation and WC farmers preferring information in point form. The farmers indicated that the presentation of SFs should be simplified, and that training should be conducted to enhance their understanding.

When examining the perceived usefulness, farmers noted that a lack of accessibility hindered the usefulness of SFs. They noted different dissemination strategies that would enhance their

usefulness, EC farmers preferred information to be distributed through administrative channels like school and clinic notice boards whereas WC farmers preferred technological mechanisms such as Apps and Websites. Both groups, however, agreed that WhatsApp or text messages would be an effective dissemination channel. The farmers noted the importance of SF information being presented in local languages and stated that SFs were beneficial in preparing themselves for the upcoming season. Farmers further highlighted the importance of the timeframe when distributing SFs (3 months before the planting season) and indicated that SFs should contain a broader range of climate information (wind, rain, hail, and temperature) along with information regarding extreme conditions (flood, heat waves, hail, and snow). Lastly, farmers wanted the climate information to be more locally specific as they stated that it would aid them in minimizing their losses due to enhanced decision making.

In relation to farmers' perceptions regarding perceived trust of the SFs. Farmers indicated that they were unlikely to trust SFs due to their high levels of uncertainty, a lack of accuracy and reliability as well as their scepticism and high requirement of scientific knowledge. They further indicated that the risks associated with SFs were too high and that their levels of trust would be based on previous experiences with the SFs. However, WC farmers indicated that they would be more likely to trust SFs if they had more information regarding the origins of the SFs. Both EC and WC farmers stated that they would trust SFs if it aligned with their indigenous knowledge systems.

The overall results indicate that there is a need to adapt and tailor SFs using the preferences of farmers. Furthermore, there is a need to train and educate farmers on the development and implementation of SFs. In order to enhance adoption, the accessibility of SFs needs to be enhanced using effective distribution channels. Furthermore, climate scientists should raise awareness regarding the nature and objectives of SFs. Ultimately, it is imperative that SFs are generated taking into account the experiences, education levels, and resources available to farmers in order to encourage the adoption of the SFs.

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Appendices

Appendix A - Ethical Clearance Certificate

**SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE
(NON-MEDICAL)**

<u>CLEARANCE CERTIFICATE:</u>	PROTOCOL NUMBER: MAORG/22/03
<u>PROJECT TITLE:</u>	Seasonal Forecasting: The experiences of farmers and agricultural experts.
<u>INVESTIGATOR</u>	Darsot Ammaarah (1684991)
<u>SCHOOL/DEPARTMENT OF INVESTIGATOR</u>	<u>SHCD/Psychology</u>
<u>DATE CONSIDERED</u>	13 July 2022
<u>DECISION OF THE COMMITTEE</u>	Approved unconditionally.
<u>RISK LEVEL</u>	Minimal Risk
<u>EXPIRY DATE</u>	31 December 2024
<u>ISSUE DATE OF CERTIFICATE</u>	11 August 2022
<u>CHAIRPERSON</u>	 _____ (Prof. Karen Milner)

cc: Prof. Andrew Thatcher (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature  Date: 11/03/2023

Appendix B – Supervisor-Supervisee Contract

THE SUPERVISOR AND THE STUDENT: 1. Will establish agreed roles and clear processes to be maintained by both parties. In the case of joint supervision, the role and responsibilities of each supervisor and the student need to be clarified. 2. Will meet regularly and as frequently as is reasonable to ensure steady progress towards the completion of the proposal, research report, dissertation or thesis. This time varies but the normal minimum requirement for face-to-face contact spread across each year of registration is: 10 contact hours for an Honours project, 15 contact hours for a Masters by coursework and research report and 24 contact hours for a Masters by dissertation and a PhD. 3. Will keep appointments, be punctual and respond timely to messages. 4. Will keep one another informed of any planned vacations or absences as well as changes in his or her personal circumstances that might impact on the work schedule. Unplanned absences or delays should be discussed as soon as possible and arrangements should be made, to catch up lost time. 5. Will ensure that research on animal or human subjects is conducted with prior approval and according to the procedures and the requirements of the relevant Ethics committee. 6. Will both complete Progress Reports on the research project as required/requested by the relevant Faculty Graduate Studies Committee.	THE STUDENT: 1. Takes full responsibility for the research and its successful completion; including managing the process under the guidance of supervisor(s). 2. Will attend such courses and lectures that are compulsory for the degree, and undertakes to catch up fully on any work, lectures and/or assignments, that are missed. 3. Undertakes to work independently under the guidance of the supervisor(s). This includes reading widely and critically to ensure that the seminal and current literature pertinent to his/her chosen topic has been identified, consulted and critiqued. 4. Undertakes to work in accordance with the academic standards expected by the University for the commensurate NQF level of qualification. 5. Is obliged to make appointments to consult the supervisor(s) and arrange meeting times convenient to both parties well in advance. 6. Should submit written work for discussion with the supervisor(s) well in advance of a scheduled meeting. The kind and frequency of written work should be agreed with the supervisor(s) at the outset of the research. 7. Written work that is submitted to the supervisor, including final submissions to examiners, should be relatively free from basic spelling mistakes, incorrect punctuation and grammatical errors. Responsibility for the accuracy of language, the overall structure and coherence of the final research report, dissertation or thesis rests with the student. 8. Cannot expect the supervisor to be proof-reader and editor of his/her work or to approve work with any of the weaknesses spelt out in 7 above. 9. Undertakes to heed the advice given by the supervisor(s) and to engage in discussion around suggestions made. Ultimately the student has to take responsibility for the quality, integrity and presentation of the work. 10. Should strive to maintain a focus on his/her research area and to work diligently within the agreed time schedule. 11. Agrees to honour agreements about ownership of the research and in accordance with the University's guidelines and rules in relation to co-authorship, copyright and intellectual property. 12. Will ensure that the work contains no instances of plagiarism, violation of intellectual property and research integrity standards, that all citations are properly referenced, and that the list of references is accurate, complete and consistent. 13. Agrees to work in accordance with the criteria of acceptability as supplied by the supervisor(s). 14. Undertakes not to place the supervisor(s) under undue pressure to submit work for examination until the supervisor is satisfied that it has reached an acceptable, examinable* level of quality.
THE SUPERVISOR: 1. Undertakes to provide guidance for the student's research project in relation to the design and scope of the project, the relevant literature and information sources, research methods and techniques and methods of data analysis. 2. Will provide guidance at the commensurate NQF level requirements for autonomy and accountability that the student is expected to demonstrate. Has a responsibility to be reasonably accessible to the students. 3. Will be prepared for meetings with the student. This includes being up-to-date on the latest work in his/her area of expertise. 4. Will expect written work as jointly agreed, and will return that work with constructive criticism within a timeframe (a suggestion of 2-4 weeks) jointly agreed at the outset of the research. 5. Will provide advice that can help the student to improve his/her writing. This may include referrals for language training and academic writing. The supervisor will provide guidance on technical aspects of writing such as referencing as well as on discipline specific requirements. Detailed correction of drafts and instruction in aspects of language and style are not the responsibility of the supervisor. 6. Will guide the student in the production of a research report, dissertation or thesis. Provision should be allowed for adequate, mutually respectful, discussion around recommendations made. 7. Will assist with the construction of a written time schedule, which outlines the expected completion dates of successive stages of the work. 8. Will encourage the student to present work at postgraduate/ staff seminars/national/international conferences as appropriate. 9. Will assist with the publication of research articles as appropriate. 10. Will discuss the ownership of research conducted by the student in accordance with the University rules on intellectual property, copyright, guidelines on authorship/co-authorship, and policy on research integrity. 11. Will ensure that the student is aware of the University's Plagiarism Policy, knows what plagiarism is, and what the consequences are for academic dishonesty and violation of research integrity and intellectual property. 12. Will ensure that the student is made aware in writing of the inadequacy of progress and/or of any work where the standard is below par. Acceptability will be according to criteria previously supplied to the student. 13. Has a duty to refuse to allow the submission of sub-standard work for examination, regardless of the circumstances. If the student chooses to submit without the consent of the supervisor, then this should be clearly recorded and the appropriate procedures followed.	We confirm that we have read and understood this statement and agree to be guided by its principles for as long as we continue to work together. Name of student: Ammaarah Darso Student Number: 1684991 Student's signature:  Name of Supervisor: Prof. Andrew Thatcher Supervisor's signature:  Name of Co-Supervisor: _____ Co-Supervisor's signature: _____ The broad area of study is: Industrial Psychology Provisional submission date is: 28/02/2023 Degree: Masters of Arts Industrial Psychology School: School of Human and Community Development Faculty: Humanities Date: 15/04/2022 Specific agreements pertaining to: ownership, joint publication, funding, confidentiality and disclosures pertinent to the Certificate of Clearance and ETD Form which the student and/or supervisor are required to sign, must be attached to this agreement as and when appropriate and kept in the Faculty Office. In the event of disagreements between the supervisor(s) and student, the parties should act in accordance with the University Grievance Policy. *Note: Consent by supervisor(s) to submit work for examination does NOT guarantee that the work will pass. The appointed examiners assess and determine whether the work is of a passable standard. (2019/09/30)

Appendix C – Participant Information Sheet

Psychology



School of Human &
Community Development

University of the Witwatersrand

Private Bag 3, Wits, 2050

Tel: 011 717 4503

Fax: 086 553 4913



Dear Sir/Madam

My name is Ammaarah Darsot. I am currently completing my Masters degree in Industrial/Organisational Psychology at the University of the Witwatersrand. As part of the degree, I am required to conduct a research project. I have chosen to look at Seasonal Forecasting and the different experiences that farmers and agricultural experts have with seasonal forecasts. I would like to invite you to voluntarily participate in my study. Participation in this study would involve an interview of approximately 30 minutes. All information provided within the interview will be confidential. The interviews will be recorded. However, only my supervisor, a third-party transcriber and I will have access to the recordings. The recordings will be kept in an encrypted folder on my computer. You may choose to only answer the questions that you feel comfortable answering. Should you wish to withdraw from the study at any time, you may do so without consequence. There are no benefits or disadvantages associated with participation in the study. Demographic variables will be collected to help describe the sample. However, no identifiable characteristics will be discussed in the write-up of the study. Participants will be given pseudonyms to ensure confidentiality. Therefore, anonymity and confidentiality of all participants and responses will be kept.

If you have any further questions or need any results of the study, please contact me or my supervisor using the details below. If requested, a summary of the study and results may be obtained approximately six months after the completion of the interview.

Thank you for your time and consideration. Please detach and keep this sheet for future reference.

Regards: Ammaarah Darsot

Andrew Thatcher

1684991@students.wits.ac.za

Andrew.Thatcher@wits.ac.za

Appendix D – Consent Form (Focus Groups Session)

Psychology



School of Human &
Community Development
University of the Witwatersrand
Private Bag 3, Wits, 2050
Tel: 011 717 4503
Fax: 086 553 4913



Title of project: **Seasonal Forecasts: The Experiences of Eastern Cape and Western Cape Farmers.**

Name of researcher: Ammaarah Darsot

I,, agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.

YES NO

I understand that I can volunteer to take part in the study

YES NO

I agree that the interview/focus group/other activity may be audio recorded

YES NO

I agree that direct quotations from my interview may be used by the researcher in their research report

YES NO

I agree that my participation will remain anonymous (my name will not be used by the researcher in their research report)

YES NO

I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on

YES NO

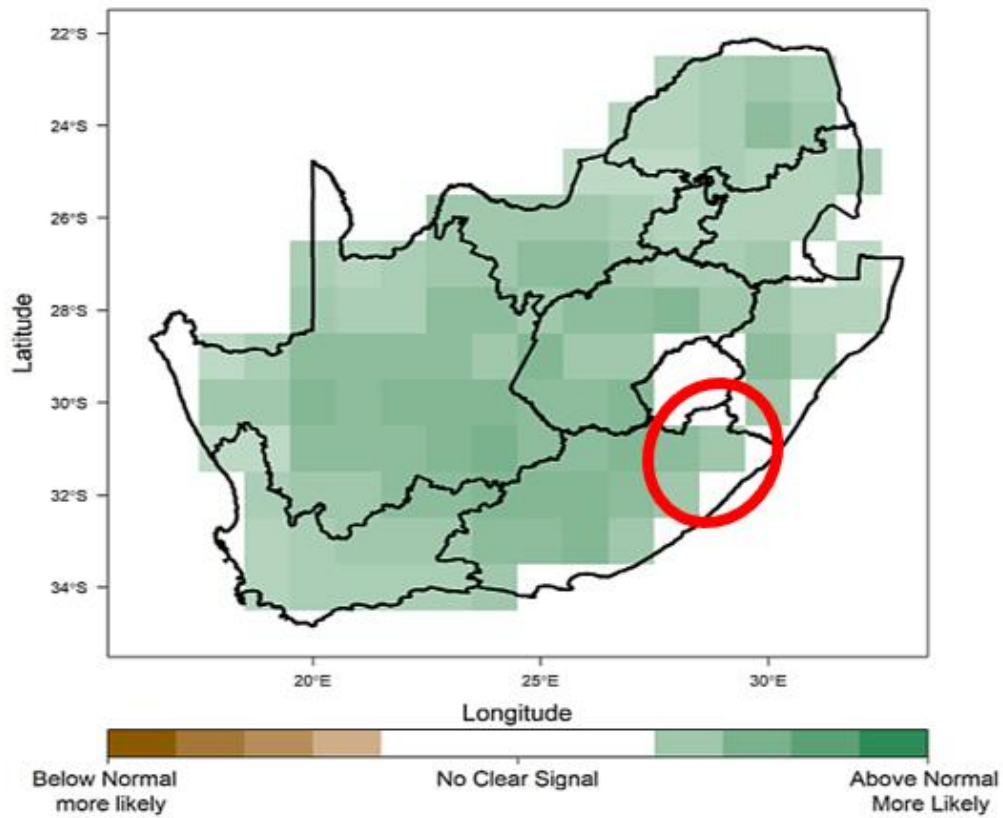
Name of participant _____

Signature _____

Date _____

Appendix E – Seasonal Forecast Outputs

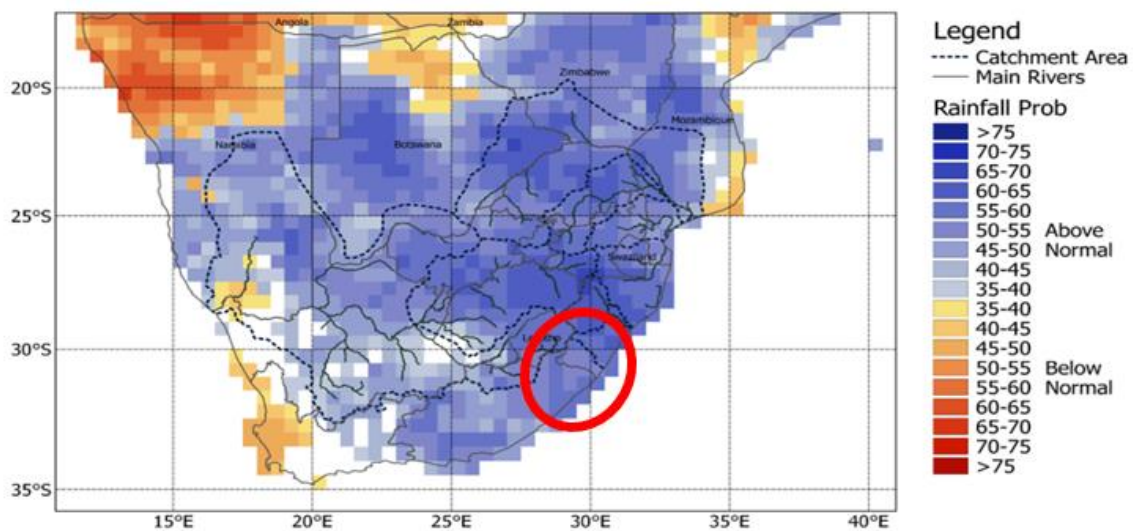
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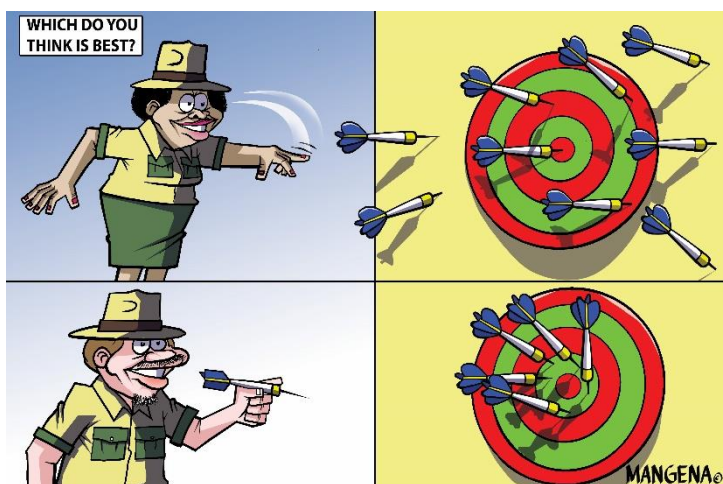
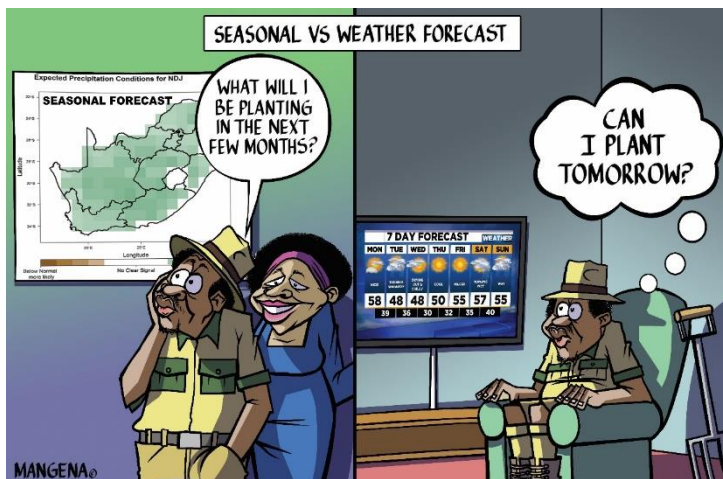
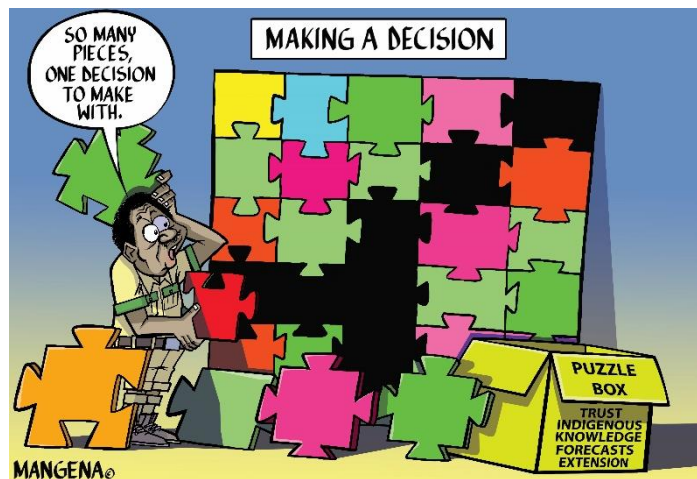
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NDJ

Rainfall; ICs: Oct



Appendix F – Workshop Presentation Documents



Appendix G – TurnItIn Report

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by Ammaarah Darsot

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