

**Building the Western Cape farmers' resilience to climate change: Assessing the
usefulness of Credibility
Salience and Legitimacy framework in linking climate change adaptation
information into action**



Submitted by

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ABSTRACT

Despite the increasing availability of scientific information to support climate change decision-making for farmers' resilience to the global challenge, a huge gap exists between knowledge development and its application in decision-making. This is exerting pressure on science to develop more actionable or decision-relevant scientific information to support planning and climate change decision-making. In the context of communicating climate change adaptation information, this study examined the usefulness of the Credibility, Salience, and Legitimacy (CSL) framework, otherwise known as the knowledge system framework (Cash et al., 2003), in bridging the disconnect between information production and its use in climate change decision-making by commercial farmers in South Africa's Western Cape Province. The study was underpinned by Cash et al.'s 2003 boundary work theory, which argues that there are boundaries at the science and farmer interface which can be managed by knowledge systems employing the CSL framework in knowledge production. As such, the researcher undertook and examined the Western Cape's agricultural climate change response strategy known as the "SmartAgri" Plan, wherein scientists and agricultural experts developed case studies and regional commodity briefs, a proxy of climate change adaptation information, to support farmers' resilience to climate change. The research looked at how these communication outputs are actionable in connection to users' perceptions of the credibility, salience, and legitimacy of this knowledge. The research consisted of an online focus group discussion with four SmartAgri scientists and agricultural experts as the producers of the information, as well as semi-structured telephone interviews with 11 Western Cape commercial farmers as users of climate change adaptation information. Findings from the interviews suggest that while there have been efforts to produce credible knowledge for enhanced awareness of climate change and its impacts on the Western Cape province's agricultural sector, the availability of salient and legitimate climate change adaptation information remains a challenge at the science-farmer interface. Factors such as limited experiential evidence, disparities in the scale and resolution of climate projections, the absence of financial support to commercial farmers, and limited involvement of farmers in the development of climate change adaptation information, continue to undermine the actionability of climate change adaptation information in the areas studied. As a result, spanning the boundary between knowledge and action has been a challenge. Nevertheless, despite these limitations, commercial farmers consider climate change adaptation information potentially useful. Increased engagement with farmers, demonstrations, and trials with farmers, documentation, and sharing of local best practices will be some of the

key steps towards developing more actionable knowledge for farmers' use in climate change decision-making.

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LIST OF ABBREVIATIONS

CSL- Credibility, Salience, and Legitimacy

DEA & DP- Department of Environmental Affairs and Development Planning

DRM- Disaster and Risk Management

DRR- Disaster and Risk Reduction.

DWAF- Department of Water Affairs and Forestry

ENSO- El Niño Southern Oscillation

FAO- Food and Agriculture Organization

GCMs- Global Climate Models

GDP- Gross Domestic Product

IPCC- Intergovernmental Panel on Climate Change

RHFAs- Relatively homogeneous farming areas

SST- Sea surface temperature

WCG- Western Cape Government

WCCCRS- Western Cape Climate Change Response Strategy

WCDoA- Western Cape Department of Agriculture

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CHAPTER 1: INTRODUCTION

Serious changes are taking place in the climate system today because of global warming, with global temperatures now 1°C higher than they were before the industrial revolution and projected to increase to 1.6–4.3 °C by year 2100 (IPCC, 2018). Southern Africa is also warming at double the global rate, with erratic rainfall patterns, floods, droughts, pests, and diseases becoming more prevalent in the region (FAO, 2020). Given the agricultural sector's reliance on environmental stability in relation to atmospheric temperatures, rainfall, soil fertility, pest infestations, and diseases, any negative shift in these variables poses a significant threat to the sector (Benhin, 2006). In South Africa, the agricultural sector in the Western Cape province is important to the country's economy, accounting for 20% of total agricultural production and 55% to 60% of agricultural exports (WCG, 2016a). Climate change threatens to undermine the country's developmental outcomes including food security, poverty reduction, and sustainable growth, with the impacts of climate change already being experienced in the Western Cape province (Midgley & Methner, 2016). Over the last 50 years, the province has already seen an increase in average temperatures of about 1°C., and these temperatures are projected to increase to 3°C–6°C by the end of the century (WCG, 2018a). The province has also experienced numerous climate-related natural disasters, with the 2015–2017 drought being the worst on record, with far-reaching economic and social ramifications for the agricultural sector (WCG, 2020; Otto et al., 2018).

With climate change continuing to change the face of the Western Cape's agricultural sector (Zwane, 2019), pressure is increasing to expedite adaptation to the changing climate through designing and implementing adaptation solutions that encompass resilience (Midgley & Methner, 2016). Resilience is a concept that stems from Holling (1973), who defined it as a characteristic of systems that can absorb changes and persist. One of the essential components of effective adaptation planning is the use of science-based climate change adaptation information to inform decision-making (Tang & Dessai, 2012; Dilling & Lemos, 2011). Adaptation measures need to be backed by scientific information on the changing climate for effective adaptation action (Kirchhoff et al., 2013a; Klein et al., 2014). Although the information deficit model—which argues that people are rational beings who can alter their behaviors and support change simply by requiring appropriate information—has been

challenged in recent years (Fleming & Vanclay, 2011), information is crucial in decision-making (Ernst et al., 2019). Information is the first step in any decision-making process, and its absence can impede effective participation in the adaptation process (Meijer et al., 2014). In the agricultural context, farmers' need for information in farm management is well established (Ingram et al., 2016). Providing adequate information on climate change impacts and adaptation techniques raises farmers' awareness and increase their capacity to adapt to the shifting climate (Popoola et al., 2020).

Nonetheless, despite the availability of both a demand for and a rise in the supply of quality climate change adaptation information, there remains a noticeable gap between the information that is being generated and that is being used in decision-making (Sarku et al., 2022). In other words, there is an "information-action gap" that numerous studies have attributed to a mismatch between what producers of climate change adaptation information (science and agricultural experts) understand as useful information and what users or decision-makers (farmers) acknowledge as actionable or decision-relevant information (Kirchhoff et al., 2013a; Dilling & Lemos, 2011; Lemos et al., 2012). This dichotomy reflects the different ways that producers and users perceive climate change adaptation information. "Producers" are those who convert raw data into more sophisticated forms, whilst "users" or "decision-makers" are those who acquire and apply climate change adaptation information (Guido et al., 2019). According to Hansen et al. (2019), producers of information frequently lack a thorough understanding of users' decision-making processes and contexts, such that the information they produce often remains unused. On the other hand, despite climate change adaptation information's potential efficacy, users may not always recognise the types of information that could be of value to them and whether science can offer practical and decision-relevant information to them (Porter & Dessai, 2017; Briley et al., 2015).

Thus, to bridge the information-action gap and better connect scientific information with climate change adaptation action, this study suggests a shift in the way in the approach to information supply. The character of climate change adaptation information and how it is produced and communicated across the science-practice interface is essential for achieving greater information adoption (Ingram et al., 2016). Cash et al. (2003), whose work this study is based on, argue that for information to influence climate change decision-making effectively, it must be deemed credible, salient, and legitimate (CSL) by its users. Credibility refers to the perceived accuracy, validity, and quality of climate change adaptation information. Salience

explicitly relates to how pertinent the information is to decision-makers' needs. Lastly, Legitimacy captures the degree to which knowledge creation is regarded to be respectful of decision-makers' different values and views, impartial in its conduct, and fair in its treatment of conflicting opinions and interests (Cash et al., 2003). Nonetheless, CSL attributes are viewed and valued differently by actors on opposite sides of the science-practice divide, and it is these disparities that make bridging the knowledge-action gap difficult (Cash et al., 2003). It is against this theoretical backdrop that this study is situated. This investigation draws its theoretical framework from the theory of boundary work, which uses the concepts of Credibility, Salience, and Legitimacy to manage tensions between science and non-science and effectively connect knowledge and action (Cash et al., 2003).

Using the sectoral climate change response strategy for the Western Cape's agricultural sector known as "SmartAgri," this study examines how selected communications outputs (DRR case study and three regional commodity briefs) were produced for the agricultural sector under the plan are actionable. Actionability is measured in relation to users' (i.e., the Western Cape commercial farmers') perceptions of the Credibility, Salience, and Legitimacy of this knowledge.

Much research has focused on making scientific information actionable at the science-policy interface (Cash & Moser, 2000; Miller, 2001), but there appears to be limited research on bridging the information-action gap at the science-farmer interface. The science-farmer interface is important as farmers are not only crucial in food production but are also the group primarily responsible for climate change adaptation in the agricultural sector. How farmers receive and apply the information is critical to understand as it influences how and with what success climate change adaptation programs will be realized on the ground (Ingram et al., 2016).

This study will contribute to overall research on bridging boundaries at the science-farmer interface for effective climate change adaptation action. The research comes at an opportune time when there is growing pressure on scientists to translate and breakdown scientific knowledge into practical tools for farmers' adaptation action (Ingram et al., 2016). The study attempts to provide insight into the mechanisms and processes that move climate change adaptation information from what scientists consider useful to what users deem useful information in relation to their contexts.

1.1 Research Aim and Objectives

In the context of communicating climate change adaptation information, the purpose of this study is to investigate the usefulness of the CSL framework in bridging the potential disconnect between information production and its use in decision- by farmers in South Africa's Western Cape province.

Specifically, the study will focus on the following research objectives:

1. Identifying CSL-related factors that deter the use of climate change adaptation information in decision-making at the science and farmer interface.
2. Examining information producers' perceptions of farmers' information needs and to what extent they perceive the selected case study and regional commodity briefs to be CSL for farmers' uptake.
3. Examining the Western Cape commercial farmers' perceptions of the plan's selected case study and regional commodity briefs in terms of CSL.
4. Identifying farmers' information needs based on their perceptions of information that is CSL.
5. Based on the objectives above, make recommendations for the development of more actionable climate change adaptation information and contribute to wider debates on bridging boundaries at the science-farmer interface.

1.2 Study Outline

The study is divided into five chapters. The first chapter has introduced the study. The second chapter will present the literature review and the study's conceptual framework. The third chapter will discuss the area of study and data collection methods. While chapter four presents and discusses the study's findings, chapter five will conclude the study and provide recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Climate Change Projections and Risks in the Western Cape, South Africa.

2.1.1 Temperature changes

Climate change is no longer a far-fetched phenomenon, with scientific consensus that the future climate will differ from that of the past due to increased warming (Nhamo et al., 2018). In South Africa, evidence shows that the country has been experiencing warming over the past five decades (WCG, 2018d). The projections are worse for the Western Cape province, which is expected to continue experiencing warming, with the most significant impact projected for the spring and summer months (Southey, 2017; Theron & Hunted, 2022). Maximum and minimum temperatures are likely to surge more in the dry inland and northern portions of the Western Cape, with minor changes upwards in the Southern Cape because of sea surface conditions and the prevailing winds (Blamey et al., 2014). Summer maximum temperatures are expected to rise by 1.5 °C to 2.25 °C across the province, with some climate models predicting temperatures as high as 3.0 °C by 2060 (WCG, 2018d). Above-average winter temperatures are also expected to increase between April and July (Southey, 2017). Such temperature projections, coupled with an anticipated increase in the frequency of extreme heat days and events, will have devastating impacts on agriculture (WCG, 2018d). High average temperatures lead to increased evaporation and decreased water levels in the face of increasing demand for irrigation water (Lenari & Bek, 2022). Adaptation responses become unavoidable in that regard (Theron & Hunted, 2022).

2.1.2 Rainfall Variability

Rainfall variability is a serious challenge that has limited agricultural production in Western Cape (Zwane, 2019). Generally, South Africa experiences average year rainfall of 450 mm, which is well under the average global rainfall of 860 mm (Zwane, 2019). Only 10% of the country receives more than 750mm of precipitation every year. The Western Cape province, which lies in the Mediterranean climate zone and is distinguished by dry summers and wet winters with an Atlantic Ocean influence, receives winter rainfall which falls from June to August (Midgely, 2005; Talanow et al., 2020). The province's annual precipitation ranges from 300 mm to over 1500 mm (Botai et al., 2017). Wet winters are a result of an equatorial shift

and a strong mid-latitude storm track in South Africa (Midgley et al., 2005; Reason & Rouault, 2005). Rainfall patterns in the province are difficult to measure due to numerous temporal and spatial variations as well as the influence of topography in the province (Blamey et al., 2014; WCG, 2018d). However, despite the difficulties in measuring rainfall patterns, there is a consensus that climate change will cause a decrease in rainfall in the province (Jordaan, 2022). This is due to the province's projected warming and drying trend, especially from 2040 and beyond (Jordaan, 2022). The total rainfall is not expected to change in the short run, but there are concerns that while the total rainfall may not have significant changes in the immediate term, the amount of rainfall days might decline, and the intensity of rainfall events might increase in the long run (Jordaan, 2022). The latter is of great concern because it will put additional strain on the Western Cape's already stressed water supplies, affecting the agricultural sector, which is one of the province's most significant users of water (Lanari & Bek, 2022). 68% of available water in the Western Cape is used for irrigated agriculture (Midgley et al., 2016)

2.1.3 Droughts

With climate change projections of a warming climate in the Western Cape, increased dry periods of higher intensity are in to be expected for the province (Jordaan, 2022). Extreme water events are an ongoing threat to the Western Cape's agricultural sector (Lanari & Bek, 2022). A typical example is the 2015–2018 drought in the province, which according to Otto et al. (2019) and Kam et al. (2021), was a result of anthropogenic climate change and was the worst drought to be recorded since the drought in 1926–1933 (Botai et al., 2017; Zwane, 2019). An increased frequency of droughts poses considerable risk to the province's agricultural sector (Dai, 2011). The 2015–2018 Western Cape drought saw heavy economic losses of nearly 5.9 billion ZAR in the sector, reductions in exports between 13 and 20%, and approximately 30 000 job losses (Botai et al., 2017; Archer et al., 2019). Moreso, nearly 17 000 cattle are believed to have died of starvation (Opiyo et al., 2015). Although the ability to accurately predict the next drought or its severity is still limited (WMO, 2019), climate change projections show future droughts for the province (Jordaan, 2022). This, coupled with rapid urbanisation and population growth, increased competition for water from both urban and agricultural users (Scholz & Methner, 2020), will lead to reduced water availability in the future (Le Roux et al., 2019). The latter is concerning considering that the Western Cape has the largest irrigation area

(Jordaan et al., 2021) and is also the province with the most significant exports of agricultural produce, earning valuable foreign exchange for the country (Jordaan et al., 2021).

2.1.4 Wildfires

Extended warming, longer dry spells, increased evapotranspiration, and increased wind speeds in the Western Cape also put the province at high risk of wildfires (WCG, 2016a; WCCCRS, 2014). The province has already experienced several climate-related wildfires, especially around the Knysna area (WCG, 2018d). Wildfires not only lead to loss of lives but can damage livelihoods and social activities (WCG, 2018d). Farms, mainly those close to natural areas, are at high risk. The occurrence of wildfires in the Western Cape is expected to increase significantly with the hotter, drier conditions. Projections indicate a 40% increase in wildfires in the west, and a 120% increase in the province's east (WCG, 2018d)

2.1.5 Other Interacting Factors

Apart from climate change, other factors affect agriculture in the Western Cape province. For instance, in many places in the Western Cape province, soil limits productive agriculture, for example, in the nutrient-poor Table Mountain Sandstone-derived soils and most of the sandy coastal plains (SmartAgri status quo report, 2016). Further, out of approximately 11 560 609 ha of the Western Cape's total farmland area, which constitutes 89 % of the province's total land, 16% (approximately 2 126 342 ha) is arable, and 320 000 ha is under irrigation (WCDoA, 2016a). The rest of the land (70 %) is under grazing (WCDoA, 2016a). Poor farming practices, overgrazing, and land clearance have also led to erosion and land degradation in the province, with a 44% decline in erosion control and ecosystem services (Scholz & Methner, 2020).

2.2 Climate Change Impacts on Agriculture and Farmers in the Western Cape

The Western Cape agricultural sector is highly developed (Scholz & Methner, 2019) and dominated by large-scale commercial businesses (Findlater, 2013). The sector's value chain is well-integrated into an international export market, contributing 12% to South Africa's total agricultural area (Scholz & Methner, 2019). The sector is well diversified, producing more than

50% of the country's agricultural exports comprising of livestock, indigenous tea, high-value fresh and processed fruits and wine (Western Cape Department of Economic Development and Tourism, 2014). Although the agricultural sector's contribution to the Western Cape's economy is just 4%, at the national level, the province has a clear competitive advantage, contributing 23% of the total agricultural Gross Domestic Product (GDP) in South Africa (Kuschke & Cassim, 2019; WCDoA, 2019).

In addition, the Western Cape's agricultural sector also has significant forward linkages with the manufacturing industry through food and beverage processing (WCG, 2016a). Food and beverage production accounts for 37% of the sector's output, much of which is exported. Strong backward linkages also exist with input suppliers such as equipment, fertilizer, feed, and packaging companies. These companies contribute considerably to the province's employment market. The production sector is estimated to contribute 71.6% of jobs in the agri-processing value chain (WCG, 2016a). The Western Cape's thriving agricultural sector is a result of its production environment. As was mentioned, it is characterized by winter and year-round rainfall, varied topography, soils, microclimates, and oceanic to inland continental climatic influences (Theron et al., 2021). For that reason, the Western Cape's agriculture sector is unique to South Africa (Theron et al., 2021).

However, despite the Western Cape's agricultural sector's significant contribution to livelihoods and the national economy, climate change impacts on the sector will be negative (Midgley et al., 2005). This is supported by the WCG (2016a), which argues that climate change threatens economic growth and food security in the Western Cape. To evaluate the entire risk and impacts of climate change on agriculture, an integrated approach of the associations between climate drivers, direct and indirect implications on crops, livestock, the production environment, and the socioeconomic situation is critical (WCCCRS, 2014). While the Western Cape's agricultural sector is highly prone to climate change and variability, the scale of impacts will differ depending on the region, type of commodities, local farming practices, natural resources, and socioeconomic factors (WCCCRS, 2014).

Due to their high dependency on consistent climatic conditions, crops are extremely vulnerable to climate change variability (Zwane, 2019). For instance, small grains like wheat are likely to be impacted by climate change in marginal production areas (Wallace, 2014). Wine production

will also be impacted negatively by warming and the decrease in water availability (Cartwright, 2002; Wand et al., 2008).

Irrigated horticultural crops are well-studied crops with well-known temperature thresholds. Any significant shift in these thresholds can have disastrous consequences for these crops (WCG, 2014). The biggest threat to horticultural crops under irrigation includes insufficient water and continued warming in the current warmest production regions (WCG, 2016a). For instance, apples and dryland horticultural produce like rooibos are already experiencing climatic stress in warmer production areas (Oettle, 2006). Although the Western Cape has a substantial water footprint for irrigated crops in South Africa (Baleta & Pegram, 2014), limited water supply, partly because of the 2015-2018 drought, which saw a 60%-86% decrease in water allocation for the Western Cape's agricultural sector, is causing crops to wither, reducing yields and profits (Kath et al., 2019). This has weakened the financial viability of agricultural production (Kath et al., 2019).

Furthermore, although it is difficult to predict with certainty at this time, seasonal changes in temperature, rainfall, and humidity can cause severe production and quality issues for horticultural crops (WCG, 2016a). While most irrigated horticultural crops, except apples, are not likely to be affected by moderate warming, extreme temperatures, such as heat waves can have severe impacts (WCG, 2016a). The 2015 - 2018 drought and heat wave can attest to this fact, given the enormous challenges that horticultural crops, particularly vegetables, experienced in the Western Cape. For example, according to Agri Western Cape (2017), cited by the WCG (2017), fruit quality (e.g., color, size, sunburn, and storage capacity) was also a huge challenge during the drought as demand decreased in critical markets and reduced the Western Capes' export market share by 4.2% (WCG, 2017). The low production can be converted to a 40-million ZAR wage loss for seasonal employees (WCG (2017).

Changes in pest species range and intensity, the development of new types of diseases, and increased weed growth are all huge threats to crop production in Western Cape because of climate change and variability (Midgley, 2016). According to Theron & Hunted (2022), pests and diseases are increasing in once cool and inhabitable areas due to warming winters (Santos et al., 2020). Exacerbating this challenge is that relatively little is known about changes in the spatial range and intensity of weeds, pests, and diseases (WCG, 2016a). Moreover, diseases and pests can be difficult to contain (Zwane, 2019).

In addition to affecting crop production and yields, livestock production, especially extensive livestock (cattle, sheep, and goats), will also be affected in numerous ways. Rust and Rust (2013) identified four main ways livestock in the Western Cape will be affected. These include changes in animal feed, grain accessibility, and feed prices; impact on livestock pastures in terms of quality and quantity; pests and diseases and pests; and the direct impact on animal health, development, and reproduction. This has also been echoed by several scholars who argue that extensive animal production will be affected primarily through the deterioration of rangeland productivity across the drier parts of the province, which in turn will affect the quality of livestock, and hence the quality of the meat. Livestock's meat quality will also be affected by infected feed animals consume (Nesamvuni et al., 2012; Archer van Garderen, 2011).

Climate change will intensify the frequency of wildfires, which will severely impact essential ecosystems such as fire-prone habitats like fynbos (WCG, 2014). Valuable perennial crops, for instance, grapevines, are often planted in or around fire-prone fynbos (WCG, 2016). As a result, farms, particularly those near these natural areas, face an increased risk of cattle loss and substantial damage to vineyards, orchards, pastures, fodder banks, storage, equipment, pack houses, and processing units. Wildfires are often challenging to control, placing firefighters (often employees) at considerable risk. With the frequency of wildfires likely to surge due to hotter and drier conditions in the Western Cape, the expected impact on ecosystems and livelihoods is worth noting (WCCCRS, 2014).

Apart from the direct impacts, several indirect impacts of climate change on agriculture will also be experienced. This includes heat stress on employees, energy supply and demand issues (e.g., cold stores) and farm and rural infrastructure. These direct impacts will have sizeable knock-on effects on and across the supply chain, including post-harvest processes like storage, packaging, processing, and transportation (WCCCRS, 2014).

The climate projections on temperature increase are clear, and the impacts are evident through the increasing number of wildfires and drought events in the Western Cape (WCG 2019/20). As climate change and its impacts continue to be experienced in the Western Cape, unless substantially scaled responses are prioritized and executed with urgency, all hard-won development accomplishments and goals hang in the balance (WCG, 2016a). Climate change

presents the Western Cape's agricultural sector with an unprecedented opportunity to catapult its development strategies to be more innovative and long-term (WCG, 2019/20). According to IPCC (2018), the time is now to start pushing for more proactive and long-term adaptive planning.

2.3 Climate Change Adaptation and Resilience in the Western Cape

With the projected impacts of climate change on the Western Cape's agricultural sector, efforts to strengthen the sector's resilience and facilitate adaptation to the changing climate are increasing (WCG, 2016a). Adaptation is the "process of adjustment to the actual or expected climate and its effects" (IPCC, 2007: 6). It can be interpreted as efforts that aim to address climate change directly, or as encompassing actions that are motivated by other ecological, developmental, and risk management concerns but also offering adaptation advantages. (Khan & Roberts, 2013). Adaptation can target both future climate changes (proactive) and present climate change adaptation shortfalls (reactive) (Wilson et al., 2020).

While adaptation is an essential strategy for managing climate change impacts, it is not the only one. Resilience is also another important strategy. The concept of resilience has also evolved significantly in climate change debates since Holling (1973:17) defined the concept as the ability to "absorb changes and still persist." According to Olsson et al. (2004:2), resilience is the capacity of a "social-ecological system to absorb disturbance and reorganize while changing to still retain essentially the same function, structure, identity, and feedback."

For many years, the Western Cape's agricultural sector has demonstrated remarkable resilience to the inherent climatic variability of the province (WCG, 2019/20). Farmers have learned and evolved their understanding of climate-related risks and management (OECD, 2009). However, the concern is that farming systems are now moving through unprecedented times where climate change is shifting familiar patterns of climate risk and impact. For instance, the global climate phenomena have increased the variability of production factors, yields, and prices (IPCC, 2014a). Risks with a low historical likelihood but devastating consequences like flash floods and heat waves have become a common feature of the climate (World Bank, 2013a; IPCC, 2012). In other instances, critical thresholds are being breached, necessitating radical and even disruptive measures for adaptation (WCG, 2016).

Resilience is an essential component of the broader suite of addressing climate change, especially considering the uncertainty about the timing and severity of climate change impacts and the evident limits to the efficacy of adaptation (IPCC, 2014a; Nkhata, 2020). Climate-resilient pathways can lead to more resilient agricultural systems, and this can be achieved through emphasizing iterative risk management premised on effective adaptation measures, monitoring, learning, and communications (Nkhata, 2020). Looking at communications, it is not astonishing that there have been increasing calls at the science-practice interface for re-visioning public engagement with scientific knowledge (Murunga et al., 2022). These calls emphasise the need to interrupt the status-quo that dictates the voices that matter in climate change communications, how people interact, in what way, and to what end (Lucas, 2021). According to (Murunga et al., 2022), meaningful iterative public engagements will result in more socially robust scientific information, thus increasing chances for resilience (Mach et al., 2020). This is also consistent with WCG (2016a), which is climate change co-management with critical agricultural actors for increased resilience (WCG, 2016a).

2.4 Smart Agriculture for Climate Resilience (SmartAgri plan)

In response to climate change impacts in the Western Cape Province, the WCG developed an innovative climate change resilience strategy known as the Smart Agriculture for Climate Resilience (SmartAgri) plan (WCG, 2016). The SmartAgri plan is a sector climate change response plan developed in a collaboration between the WCG, namely the provincial Department of Agriculture (DoA), the Department of Environmental Affairs and Development Planning (DEA & DP), as well as an interdisciplinary research group from the University of Cape Town and other affiliated research institutions. The plan is an extension of the Western Cape Climate Change Response Strategy (2014) and was designed "to equip agriculture to respond to climate change risks, and opportunities through innovation, leadership, and united strategic action" (Farrel et al., 2020: 2). The SmartAgri plan's response framework focuses on four key strategic areas, namely: supporting climate-resilient agricultural systems; advancing good cooperative governance and effective climate change risk management planning; and strengthening disaster risk reduction, monitoring, knowledge, and research in the agricultural sector (WCG, 2020).

The SmartAgri plan has been dubbed an innovative and scientifically robust plan of action for climate change resilience following its extensive review of climate change and the Western Cape's agricultural sector (WCG, 2019/20). The rationale behind the plan is that increasing knowledge of the sector's climate change impacts and vulnerabilities across spatial and temporal scales, attained through research and constant learning, guides the design and execution of suitable response strategies for the sector (WCG 2019/20). According to the WCG, 2019/20, since the launch of the SmartAgri plan in 2016, the plan has made waves in the agricultural sector by providing practical support and guidance on climate risk management.

2.5 SmartAgri Information Outputs

The government's support towards farmers in the plan is strongly based on increased production of science-based information through research and the distribution thereof. The SmartAgri plan developed several knowledge outputs to support the agricultural sector (including farmers, agri-businesses, and government agencies) with practical information for their short-term planning and long-term decision-making (WCG, 2020). Among this knowledge products are 16 regional commodity briefs, which provide locally specific climate-related information, including risks and opportunities for various commodities and regions in the Western Cape. These regional commodity briefs are available in English, Afrikaans, and isiXhosa (Trautmann, 2017). Also produced were six case studies aimed at inspiring stakeholders throughout the agricultural sector by showcasing successful climate change adaptation and mitigation practices in the Western Cape. The case studies highlight the province's barriers and enablers for effective climate change adaptation and mitigation. (Trautmann, 2017).

A fundamental assumption underpinning these information outputs is that when proper knowledge is produced, farmers, for example, will obtain this knowledge and translate it into practice (WCG, 2019/20). Nevertheless, farmers' decision-making does not follow a linear sequential process reformulation (Robert, Thomas & Bergez 2016). Farmers' decision-making evolves much more slowly and incrementally, with episodes of iteration and reformulation. (Robert, Thomas & Bergez 2016). Moreover, as scores of institutions, programs, and projects are increasingly developing knowledge products to support adaptation to climate change, the

concern is to what extent these knowledge outputs provide information that users need and if the users know exactly the kind of information that can help them manage climate change risks. Often, users' information needs are going unmet, or in some cases, users may need help understanding how information can be useful in their decision-making (Jagannathan, 2019). This necessitates the need to broadly understand the mechanisms and processes that inspire farmers' responsiveness to information and, in turn, the contexts which inform these responses (Goldberg et al., 2020)

2.6 The Role of Information in Climate Change Adaptation

The role of information and its link to climate action has been a topic of discussion over the years, especially in relation to its efficacy and overall impact on farmers' behavior change (Fleming & Vanclay, 2011). This can be demonstrated by scholars who have contested the validity of Macnaghten and Jacobs (1997)'s "information deficit model," which asserts that people are sensible beings who merely require adequate information to make informed decisions and change their behaviors in support of political petitions or scientific warnings (Suldovsky, 2016). The major concern with the information deficit model is how the model presumes a simplistic relationship between individual awareness and collective climate change action, where information is presumed to follow a straight path from source to the audience to action (Marunga et al., 2022). According to Marunga et al. (2022), this approach has loopholes because it overlooks essential issues such as contexts, personal and social norms. While these arguments are valid, information does influence climate change decision-making. With the changing climate globally, the demand for effective climate change messaging, public engagement, and education to increase policy support, collective action, and behavior change is pressing, as evidenced by calls for science institutions to increase the dissemination of climate change education (Hochachka, 2021). Increasing information on climate change impacts is a powerful way to improve the planning, execution, and adoption of climate change adaptation strategies (Owusu et al., 2020). Popoola et al. (2020) also argue that providing sufficient climate change information enables farmers to acclimatise to life-threatening climate conditions, as their ability to cope and acclimatise to the changing climate efficiently is solely based on knowledge levels and access to information. According to Popoola et al. (2020), people generally base their decisions on the information they have. Thus, if current and relevant

information is not properly developed and shared with information users, adaptation to climate change may be challenging (Ingram et al., 2016).

Nonetheless, for this information to have an impact on farmers' decision-making, the nature of climate change adaptation information communication across the science-practice interface, and the processes involved are critical (Ingram et al., 2016).

2.7 Barriers to Use of Information in Decision-making

Despite the well-documented risks of climate change to lives and livelihoods in the global South, knowledge about these risks still needs to be better integrated into planning and decision-making (Harvey et al., 2021). Several studies have been conducted to understand better the factors that impede this integration. Harvey et al. (2021); and Meijer et al. (2014) highlighted extrinsic and intrinsic barriers to applying adaptation information in decision-making. Extrinsic barriers include individual constraints, external environment characteristics, and innovation characteristics that impede participants' responsiveness to information. For instance, individual constraints include factors such as the farmer's traits, i.e., personal traits like (age, sex, marital status, etc.), socio-economic traits (education, income, possessions etc.), and personality traits (self-confidence, independence, etc.), among others. Second, external environmental barriers include geographical settings (soil quality, topology, climate, proximity to markets, etc.), societal culture (religion, language, social norms, and values, etc.), and political circumstances (land tenure and access rights, national policies, government structure, the state's political orientation, the presence of political freedoms and laws,). Lastly, the innovation's characteristics can operate as a barrier. In the case of agricultural innovations, factors such as the costs and advantages of the technology, including its impact on incomes, food security, soil fertility improvement, health, and nutrition, as well as costs associated with equipment, buying inputs, controlling pests, and diseases, etc., which affect adoption (Meijer et al., 2014). Intrinsic barriers, on the other hand, relate to factors such as knowledge, attitudes, and perceptions (Meijer et al., 2014). Fleming and Vanclay (2011) categorized barriers to using climate change adaptation information in decision-making into practical and conceptual barriers. Practical barriers relate to the practical dimensions of the identified measures, including individual motivation, traits, and skills; resources; time; social infrastructure; convenience; ease; flexibility; and divisibility (breaking down a change in behavior into the

necessary steps) (Rogers, 1983; Vanclay, 1992; McKenzie-Mohr & Smith, 1999; Pannell et al., 2006). Conceptual barriers, on the other hand, relate to comprehension problems and people not using information because of the complexity of the subject matter (Fleming & Vanclay, 2011).

Traditionally, theories about decision-making processes have mostly concentrated on extrinsic barriers like the features of the technology and characteristics of the external environment. Intrinsic barriers, particularly those connected to the information itself, have recently started attracting the attention of scholars, for instance, the characteristic of the climate information itself (its credibility, salience, legitimacy, and accessibility); (Cash et al., 2003; Jones et al., 2017) and how that information is communicated (Fleming & Vanclay, 2011). This is because gathering information is the first stage of any decision-making process (Meijer et al., 2014). The information a person has about a new intervention or technology is the foundation for their perceptions and attitudes toward the intervention (Meijer et al., 2014). Hence, this suggests the need to put more effort into improving the efficiency of knowledge production and exchange. (Hegger et al., 2012; McNie, 2007).

The knowledge production process should not be disconnected from its social context (Popoola, 2020). Many of the limitations and constraints of use of climate change adaptation information are due to a lack of a more comprehensive understanding of users' decision-making environments. (Dilling & Lemos, 2011). This is backed by Goldberg et al. (2020), who argue that information needs to pay attention to the context within which it is produced, communicated, and received. Behaviors are embedded in various contexts and circumstances and are linked to institutions, social networks, and geographic contexts (Cash et al., 2020). Thus, public communications need not focus only on simplistic information barriers such as access, targeting, or conceptualization challenges but there is need also to consider challenges of context that might inhibit people's ability to act on the information they receive (Cravens, 2018; Wong- Parodi et al., 2020). Harrison et al. (1996:215) call these "practical and discursive limitations of context", including the degree of uncertainty embedded in climate change adaptation information, the assessment scale that climate change adaptation focuses on, which often differs from the scale required for a possible adaptation response; the level of skill needed to exploit the information; trust issues between producers of information and its users as well as institutional barriers, both formal and informal (Pearman & Cravens, 2022). These issues, if ignored, affect users' perceptions of the information's credibility, salience, and legitimacy. This

suggests a need for public communications to become more sensitive to the complexities of farmer decision contexts and the information production process to support farmers with the information they need (Hochachka, 2021). The following section will discuss the CSL contextual factors in greater detail.

2.8 Conceptual Framework

2.8.1 Boundary Work Theory

As noted at the outset, this study locates its theoretical framework against the concept of “boundary work”. The notion of boundary work can generally be defined as the negotiation processes at the interface between different communities of knowledge (ie, science experts and farmers in this context) (Clark et al., 2016). The concept of boundary work was originally developed in the mid-1980s in the field of science, technology, and society (STS) to help distinguish "science" from "nonscience" (Jasanoff, 1987; Jasanoff, 1990). It was later applied by Cash et al. (2003) in their seminal work on knowledge systems to explore how boundaries at the interface between science experts and policymakers can be understood and managed. Cash et al. (2003) redefined knowledge systems to include programs or any institutional arrangements that successfully use science and technology to enhance decision-making for long-term development (Kirchhoff et al., 2013a). According to Cash et al. (2003), boundaries exist at the interface between different communities of knowledge. This is essentially a result of differing epistemologies, ways of framing problems, and viewpoints informed by different contexts, experiences, values, interests, and life-worlds between these communities. Specifically in relation to climate change adaptation in the agricultural sector, different objectives, approaches, and work contexts have been identified at the science-farmer interface (Eshuis & Stuiver, 2005.; Ingram et al., 2016; Mccown, 2001). These differences often result in tensions between scientists and farmers regarding important concepts such as what constitutes "useful information, reliable evidence, convincing argument, procedural fairness, and appropriate characterization of uncertainty" (Ingram et al., 2016).

Although boundaries between science experts and farmers have always served an important purpose (for instance, protecting the credibility of science and organizing and allocating authority), these boundaries create barriers to communication, collaboration, integration and

action, factors that are crucial in tackling complex and wicked problems such as climate change (Cash et al., 2003). According to Cash et al. (2003), for a knowledge system to be effectively translated into action, these systems must strongly manage boundaries between experts and decision-makers. Drawing on the CSL framework, Cash et al. (2003) argue that climate change adaptation information is likely to be more effective in influencing action if it is perceived by decision-makers to be CSL. For example, information is likely to be considered credible if the science is valid, accurate, high quality, backed by peer review, or led by trustworthy institutions (Kirchhoff et al., 2013a).

To be perceived as salient, information must be sensitive to the context of and tailored to decision-makers' needs across ecological, temporal, geographic, and administrative scales. To ensure the information legitimacy, the information must have been developed and shared in a transparent, open, and recognizable manner that is devoid of political bias (Kirchhoff et al., 2013a). However, actors from different sides of the science–practice boundary may have different perceptions of what CSL information constitutes, and it is these disparities that make boundary spanning a challenge (Ingram et al., 2016).

For CSL to be realized, the development of climate change adaptation information must be guided by an appreciation of how its users interact with it (Furman et al., 2011). This necessitates more than simply finding a "fit" between information requirements, types, formats, and sources. Instead, it must be acknowledged that CSL is socially assembled and shaped by who the users are and what they value and believe. As a result, it is critical to have a deeper understanding of the web of social identities and associations within which knowledge-based decisions are entrenched (Dilling & Lemos, 2011; Frank et al., 2011).

2.8.2 Conceptualizing Credibility, Salience, and Legitimacy: Boundaries at the Science and Farmer Interface

2.8.2.1 Credibility

Credibility refers to the nature of information, its method of production, and perceived validity (Cash et al., 2003). In the field of science, Credibility relates to whether users perceive information to be meeting scientific plausibility and technical adequacy standards (Asplund,

2018). Credibility can be used to assess users' perceptions of the quality of science behind disseminated information (Kirchhoff et al., 2013). Ingram et al. (2016) argue that for information to be credible, it should be perceived by its users to be accurate, valid, and high-quality.

For scientists, Credibility has long been the guiding standard; credible science can inform decision-making (Cash et al., 2003). Authority has also traditionally been given to scientific information due to its rigor, systemic approach, and rationality (Ingram et al., 2016). However, the authoritative status and legitimacy of scientific information is increasingly becoming a contested issue (Ingram et al., 2016), with the growing appreciation that "plurality of legitimate perspectives" is the panacea to understanding and crafting solutions to complex socio-ecological systems, (Cash et al., 2020: 2).

Despite the changing landscape, Credibility remains an essential attribute in guiding climate change adaptation and has long been recognised to affect how farmers receive and use information (Ingram et al., 2016). However, Credibility can be understood differently across boundaries, where there can be clashes, impositions, consultations, tactical adjustments, and compromise over knowledge, especially regarding the definition of valid and true knowledge (Ingram et al., 2016). For instance, when science enters the farmers' social arenas, their experiences with a particular scientifically derived piece of advice often conflict with their own observations and knowledge (Riley, 2008). In such cases, information can be challenged and negotiated (Giller et al., 2008; Long, 2001).

In communicating climate change adaptation to farmers, Credibility can be limited by several factors, including the inherent uncertainty and complication of scientific information (Hammill & Tanner, 2011; Harvey et al., 2014). According to Kirchhoff et al., (2013a), many of the barriers to the use of information in decision-making are a result of users' perceptions that scientific information is associated with much uncertainty and lacks the perceived level of precision and dependability required for use in decision-making (Kirchhoff et al., 2013a).

Uncertainty can result from a lack of information specificity to users' decision contexts, insufficient theoretical understanding of the interactions in the environmental system, and the inevitable insufficiency of Global Climate Models (GCMs) in representing nature's complexity. For instance, although there is growing confidence in climate change projections,

there still needs to be more certainty, specifically regarding the magnitude and timing of the projected changes (Tang & Dessai, 2012). While climate change predictions for the mid-to-end of the century are well established, the short-term period between now and the mid-century is more variable, which poses a considerable challenge for decision-makers who might need to plan for the medium to long term now (WCCRRS,2014).

Moreover, Credibility can be affected by the often-excessive focus on disciplinary knowledge from academic settings, which ignore other knowledge sources and disciplinary perspectives (Ogar et al., 2020). According to Kirchhoff et al. (2013a), there is no such thing as science produced separately from practice. Several scholars have argued for the need to incorporate other ways of knowing to address the complex challenge of climate change (Ogar et al., 2020). This is because the science and practice interface are a mutually formed space in which social exchanges between producers and users of scientific research alter the facts about the natural world under review (Cash et al., 2020). Also closely related to this point and affecting the credibility of climate change adaptation information, is the reliance of information producers on a single source of climate data, for instance, national climate scenarios, which if wrong may result in widespread vulnerability. Thus, to handle the uncertainty associated with users' unique decision contexts and the uncertainty encoded in climate data, users prefer having a portfolio of information to base on (Kirchhoff et al., 2013a).

Turning to understand how users judge Credibility, Ingram et al., (2016) argue that decision-makers use multiple ways to judge the credibility of information, including trustworthiness and expertise. According to Asplund (2018), Credibility is shaped by three aspects: source credibility, content credibility, and process credibility (Asplund, 2018). "Source credibility" relates to users' credibility perceptions of various information sources (climate experts, politicians, and social institutions). In this regard, Credibility is assessed "by proxy," where the credibility of information is judged by the participants involved (Individuals regarded as experts lend credibility) or by the organizations involved (organizations with a track record of getting valid results to accrue credibility). The higher the authority or perceived expertise of the source of information from a user's perspective, the stronger the message resonates (Benford & Snow, 2000).

Generally, users only partially depend on formal sources of information, such as scientists and government actors, for climate change advice. They rely on a variety of informal

communicators (Sleeth-Kepler, Perkowitz & Speiser, 2017), including civil society organizations (Amars et al., 2017; Twongyirwe et al., 2015); climate advisory services (Reinecke, 2015); and religious leaders (Li et al., 2016). Government actors are ascribed low credibility as there is often the assumption that they always have politically motivated agendas that do not have people's interests at heart (Asplund, 2018). For scientists, Kotcher et al. (2017) found that while their perceived credibility is generally high, scientists' credibility suffers when they advocate for specific policies.

Users also often ascribe higher credibility to information sources that are accessible and have experience-based argumentation (Asplund, 2018). For instance, Furman et al. (2011), in their study on organic farmers, found out that farmers trust other farmers as their information source, due to their long-term, place-based experience. In their study, they demonstrate that successful organic growers that have demonstrated technical innovation serve as "information nodes" and mentors to new farmers.

Extension services are also ascribed much credibility by farmers as they are metaphorically seen as knowledge banks (Asplund, 2018). In addition, Credibility can also be related to information providers' rhetorical skills and credentials (Moser, 2010). For example, certain messengers, such as respected community leaders, tend to send psychological signals that instill trust in the information (Moser, 2010). Interpersonal characteristics such as humility and respect for others influence credibility perceptions (Brugger et al., 2015). Taken together, studies of source credibility suggest that climate change adaptation information must account for climate change facts and its "feel" (Carlton et al., 2015: 8).

"Content credibility," on the other hand, is linked to perceived political and scientific uncertainties, which affect farmers' perception of valid knowledge. Political uncertainty concerns the unpredictability of political and legislative factors that can make decision-making difficult. For instance, a person's political leanings can weaken the credibility of scientific information among more conservative users (Asplund, 2018).

On the other hand, scientific certainty is concerned with science's ability or inability to make reliable predictions and the differing requirements for evidence. For instance, some farmers require scientific validation to make their decisions, while others look for experiential knowledge (Asplund, 2018). For experiential knowledge, information demonstrating where the

claims have worked is perceived as credible information (Ingram et al., 2016). Evidence-based adaptation information, including case studies, can thus be valuable (Ingram et al., 2016).

There are other farmers, however, who prefer information consisting of a mixture of practical experience and scientific validation (Adamsone-Fiskovica & Grivins, 2022). These farmers value agricultural extension services' knowledge because they are perceived as knowledge brokers, better at connecting scientific research to agricultural practices. (Asplund, 2018). While some scholars, such as Ingram et al. (2016) and Young (2016) have emphasized sense-making processes based on experience and association, others, such as McCrudden et al. (2016), highlighted author expertise as a factor in content credibility. Taken together, studies of content credibility suggest that content credibility is closely related to audience perceptions of knowledge production and methodological validity. Process credibility emphasizes the importance of participatory methods of knowledge production to increase the credibility of climate change adaptation information (Asplund, 2018). Ingram et al. (2016) have stressed the importance of co-producing information products with users to promote the process credibility of climate change adaptation information.

2.8.2.2 Saliency

With the substantial gap between information usually accessible on climate change adaptation and information required to support climate change decision-making, the importance of compatibility of information with the needs of farmers is well recognised (Ingram et al., 2016). Saliency is a related concept that refers explicitly to how information is pertinent to the decision-maker's needs. (Clark et al., 2016). What constitutes relevant knowledge differs according to the user. This is because users, especially farmers, are different and their information demands differ (Ingram et al., 2002). In the context of climate change adaptation information, Jagannathan (2019) argues for the need to comprehend the information's inherent value from the decision-makers' vantage point and what decision-makers look for in information.

A classic pitfall for Saliency and a barrier to the use of climate change adaptation information in decision-making is the development of information that has little relevance outside of it, including no connection to a decision-maker's real-life context (Toth & Hiznyik, 1998). For

instance, Saliency is a function of content and timing (Furman et al., 2011). Information that is too general or narrow in scope or scaled inappropriately for the decision-maker, can fail to trigger action for lack of Saliency (Kingdon, 1995, cited in Nissan et al., 2019). According to Kirchhoff et al. (2013a), the assessment scale on which climate science frequently focuses does not always correspond to the scale necessary for a potential adaptation response. This is due to a lack of understanding of decision scales. For instance, while climate modelling efforts are useful, they typically provide climate-related information of climatological or meteorological relevance on a larger scale (e.g., large-scale atmospheric patterns as well as temperature and precipitation averages and extremes), which decision-makers do not always consider actionable (Swart et al., 2017; Briley et al., 2015). According to Swart et al. (2017), this information, which is generally distinguished by the availability of vast amounts of data with broad spatial and temporal coverage (long time series), is often less relevant to decision-makers.

Climate information requirements of decision-makers are frequently influenced by their local sectoral contexts and decision-making contexts (Guida & Howarth, 2022). For example, some farmers plan on an annual basis and may not find longer-term helpful information. This is often a result of uncertainties associated with long-term information (Nissan et al., 2019). Furthermore, decisions differ depending on the type of farm, with each demanding very specific types of climate change adaptation information. Annual crop growers may have different planning timescales and information needs than perennial crop growers (Jagannathan, 2019). Unlike perennial farmers, annual farmers often deal with dire and short-term risks (Owusu et al., 2020). Thus, these farmers may be interested in knowing when the rains will begin during the planting season, the number of days when temperature will be low during the growing season, or the intensity and frequency of specific rainfall events (Briley et al., 2015; Mote et al., 2011). Climate change adaptation information could, therefore, easily translate into action if the information is published in a timely manner (Carr et al., 2020; Carr & Onzere, 2018). Climate change adaptation information that is reliable and informs decision-makers about issues on their priorities is of high importance (Jagannathan, 2019). This necessitates the need to disseminate information at various scales to cater for different users, including real-time data, weather, and seasonal forecasts, as well as climate change predictions (Singh et al., 2018).

Moreover, as scientists continue to increase the availability of larger-scale climate indicators in meteorological units, it is critical to consider to what extent these indicators are decision-relevant (Hackenbruch et al., 2017; Vano et al., 2019). According to Swart et al. (2017), decision-makers find information on climate change impacts in biophysical terms more salient, for instance, information on flood risks, crop yield loss, and, in some cases, impacts on valued societal characteristics such as human health and well-being, as well as economic damages, such as damages associated with floods. Farmers are also interested in crop-specific climate forecasts and forecasts that cater for crop-relevant climatic metrics (time scales, spatial scales, and skill levels) (Swart et al., 2017). However, some types of climate information are not readily obtainable in the scientific literature, Singh et al., 2018). For instance, the availability of high-quality climate change impacts in biophysical terms is limited as most of these indicators are not regularly monitored. Coordination and harmonization of such indicators is also far less organized than it is for climate data. Data on societal impacts is even scarcer and more fragmented (Swart et al., 2017).

Salience is also a function of comprehension and accessibility. Case studies across Africa highlight issues of comprehension and accessibility as a major barrier to the use of information in decision-making (Sarku et al., 2022). According to Ross & White (2018), most adaptation communicators tend to focus on technical data, which decision-makers fail to comprehend. If farmers are unable to comprehend the information provided, they will use it inappropriately or not at all (Guido et al., 2019). Producers and users of information often interpret technical language differently (Sarku et al., 2022). Thus, risk communication specialists have emphasized the need to identify where scientists and non-scientists diverge in their comprehension of scientific information (Taylor, Dessai, & de Bruin, 2015). This is important especially for climate indicators (derived from climate modelling experiments or observations), which are usually presented with a high level of detail and little post-processing (raw data). This information needs to be presented clearly and concisely with little technical skills required from farmers (Swart et al., 2017).

In terms of accessibility, if, for example, information is disseminated through web portals, it will only reach those who have internet access. Many climate change institutions have information portals as a key deliverable (Swart et al., 2017). However, a key consideration worth noting is the "Portal Proliferation Syndrome" which can be experienced by users where they may be unsure of where to go or how to interpret the available data (VanderMolen et al., 2019).

It has also been argued that most of these platforms providing climate change adaptation information are still primarily supply-driven and not user-oriented. This calls for better knowledge of the users and their needs (Swart et al., 2017). Instead of stressing the need to supply and transfer knowledge to users (also known as "push"-style communication), it is critical to transform the knowledge creation process so that the ontological pluralism of producers and users is used to develop new, actionable knowledge. (Dilling & Lemos, 2011; Mach et al., 2020). In this regard, knowledge brokers may be critical in acting as a filter, interface, and translator between producers and users of knowledge (Hammill et al., 2013).

Furthermore, Salience challenges can play out in a broader context of complex decision-making for climate change adaptation, where there may be diverse barriers and opportunities, economic trade-offs, and transaction costs to consider, potentially limiting the ability to adapt to climate variability and change. (Dumbrell et al., 2016). For instance, climate change adaptation communicators tend to focus on the environmental narrative (saving the planet), which in most cases invokes "not my job" responses from farmers (Ross & White, 2018). Before saving the planet, farmers are more concerned about transaction costs and economic trade-offs for shifting to new practices recommended in adaptation communications. These competing priorities have implications for producing relevant science information for users. Ingram (2016) stresses the importance of win-win narratives when trying to persuade farmers, environmental narratives are mixed with the economic co-benefits and synergies of adaptation practices. Singh et al., (2018) also share the same sentiments and argue that to increase motivation for and acceptance of adaptation should be able to demonstrate economic utility for end users. Information which puts weight on humanity's ecological responsibility and is accompanied by emotionally laden tactics is unlikely to evoke responses unless strongly linked to matters of financial concern. Thus, the links between financial problems and climate change must be explicitly highlighted. For example, issues related to cost reduction are more salient than describing other general impacts, that have merely implied financial benefits.

Nevertheless, on the other hand, Porter & Dessai (2017) raised an interesting perspective of how farmers' climate change adaptation information needs may be difficult to elicit due to farmers' not instantly realizing how scientific information can be of use to them or how science can offer relevant information for decision-making with reasonable skill. Earlier, we saw how farmers were argued to prefer short-term-oriented climate change adaptation information over long-term climate change adaptation information. However, several scholars have argued that

for farmers' effective adaptation to climate change impacts, sensitization about the utility of longer time-scale oriented adaptation information is necessary (Adger et al., 2005; Dessai et al., 2009). According to Jagannathan (2019), a sole focus on short-term adaptation can become a sticky challenge in the long run because these short-term coping mechanisms have the potential to preclude the crucial opportunity window for more transformational adaptation measures (Jagannathan, 2019). For instance, adapting to the next dry season is different from adapting to a future in which 13 of the next 20 years are projected to be dry (even if that projection is only 50% likely). Ignoring longer-term climate trends can be very costly (Jagannathan, 2019), as was evidenced earlier by the impacts of the 2015-2018 drought, which resulted in R14 billion worth of losses for the Western Cape's agricultural sector, Zwane (2019). Despite uncertainties underpinning long-term related adaptation information, research suggests that information on broad trends helps in better planning, for instance, in making long-term decisions such as risk management, planting, hedging, location, making larger capital investment decisions, and selecting resilient crop varieties, among others. (Nicholas & Durham, 2012). According to Singh et al. (2018), actions that focus on short-term information and leave out long-term information may result in maladaptation. Both short- and long-term climate information can help decision-making across spatial and temporal scales, challenging how risks and uncertainty are perceived, prepared for, and managed (Singh et al., 2018).

2.7.2.3 Legitimacy

Legitimacy relates to the degree to which information development is respectful of conflicting values and beliefs of decision-makers, unbiased in its conduct, and fair in its management of contrasting opinions and interests (Guida & Howarth, 2022; Cash et al., 2003). Legitimacy refers to the quality of stakeholder participation in the information production processes (Guido et al., 2019). According to Hansen et al. (2019), the difficulty in translating information to climate change adaptation action is a clear demonstration of institutional arrangements that have failed to give decision-makers a voice in climate change adaptation information products. The democratic ideal of stakeholder participation in community and risk management contexts is well recognised (Leeuwis & van den Ban, 2004). This is in part due to perceptions of the disconnection of science with issues and problems on the ground following imposed authoritative and reductive models, which frequently fail to match people's experiences in the real world. (Guida & Howarth, 2022). Another challenge to Legitimacy is the perception of

political bias. Specifically, Sumberg et al. (2013) postulate that scientific interest in climate change cannot be considered neutral. There are concerns about political interests driving the climate change narrative, and as a result, adaptation action is subject to dispute (Ingram et al., 2016). This is apparent in the range of farmer perceptions about the evidence and perceptions on the reliability of projected climate change impacts (Prokopy et al., 2015).

This resistance, together with a general increase in contestations against scientific supremacy, has seen a surge in methods grounded in principles of inclusivity, where people have a legitimate right to participate in processes that directly affect them (Ingram et al., 2016). Here, inclusiveness involves more than merely communicating science to farmers but increasing multidirectional interactions as well as farmer participation in the information production process. (Kirchhoff et al., 2013a). Ingram et al. (2016) stress the importance of iterative processes and fostering communication between producers and users of information, especially considering the complexity of climate change adaptation. The interaction process itself alters the decision-makers' perceptions and behaviours as information crosses boundaries and between producers and users in highly iterative forms of knowledge development and usage (Lemos et al., 2012; Lemos & Morehouse, 2005). It also helps producers and users of science adaptation information to address any potential disagreements and build consensus, which, in turn, help reduce information use barriers such as communication, trust, legitimacy, information accessibility fit (Pellizzoni, 2010; Lemos et al., 2010; Dilling & Lemos, 2011). This is supported by Kirchhoff et al.(2013a), who argue that information produced through participatory processes is more likely to receive decision-makers' buy-in, be deemed legitimate, and more likely to foster trust and enhance communication. Moreover, by being inclusive, transparent, and incorporating various forms of knowledge (e.g., indigenous, scientific, lay knowledge), participatory forms of information production help iron out the inequity that is often introduced by scientific expertise (Kiparsky, Milman, & Vicuna, 2012), thus amplifying the role of society in science and science in society (Kirchhoff et al., 2013a).

Nevertheless, on the contrary, while there are strong suggestions that increased participation of users can boost Legitimacy and the development and utilisation of decision-relevant science, there are concerns as to whether merely bringing scientists and decision-makers together is sufficient for this monumental task (Jagannathan, 2019). Participatory information production and governance processes have their own difficulties, including the reconciliation of participants' diverse values, worldviews, and epistemologies. Such processes also require

immense human resource support to execute (Kirchhoff et al., 2013), and information democracy is not always guaranteed, particularly when the use of scientific information becomes a source of influence for some groups over others and an instrument of inequity in power distribution among participants (Ingram et al., 2016). For example, Lemos et al. (2010) show how Brazil, using reservoir charge and discharge scenarios within river basin committees provides participants with technical knowledge authority over other members when making water allocation decisions.

Fig 1: CSL Framework

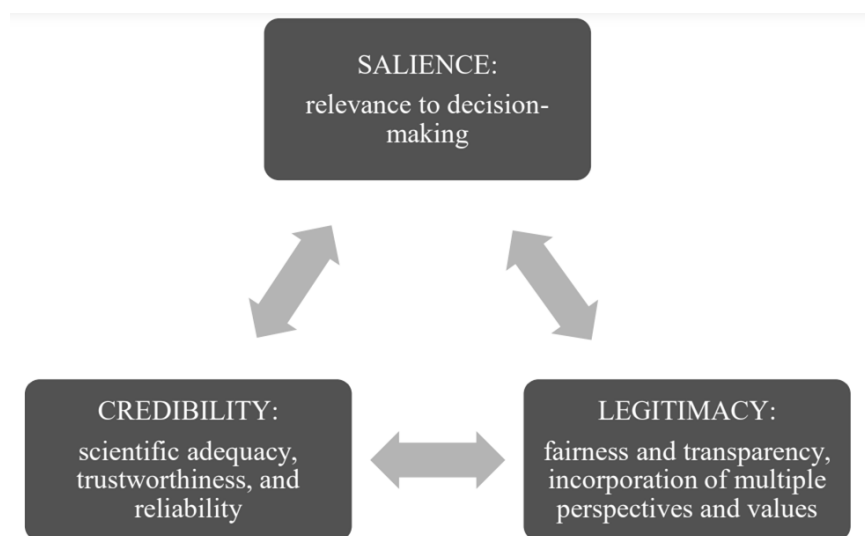


Figure 1 The CSL framework and definitions, reproduced from West et al., 2018

2.9 CSL Framework Caveats

The CSL framework, as shown in fig.1 above, is a valuable framework for linking information to action as it allows stakeholders to assess what comprises usable science and considers the entire process (from conception to dissemination) of the science in question. (Kirchhoff et al., 2013a). The versatility of this framework is evident in its application in various research initiatives globally, including how the framework supported the use of climate forecasting by farmers and water managers in Australia and water managers in Hawaii (Buizer, Jacobs & Cash, 2010; Wallington et al., 2010); the Columbia River basin's natural resource management and a variety of UK users (Tang & Dessai, 2012). Assessments deemed to be salient, credible, and legitimate have been found to be more successful (Farrel & Jager, 2006). In this regard, success includes both the usability of the information and the process of producing it. However,

a major challenge with this framework is how to bolster CSL more effectively and manage the trade-offs that become necessary when working across boundaries (Cash et al., 2003). For instance, empirical observations suggest that CSL attributes are frequently tightly coupled; improving one can result in a decrease in another. Thus, in the context of Legitimacy, information that is credible and salient to farmers may not influence farmers if they believe their views and concerns have been ignored (Cash et al., 2003). Obtaining these three attributes at the same time may thus be difficult, as trade-offs between them may have a negative impact on the overall perception of information usability. Nevertheless, deliberate efforts to balance Credibility, Salience, and Legitimacy within and across a knowledge production system's multiple boundaries will more likely influence action than ignoring these challenges (Cash & Belloy, 2020).

CHAPTER 3: METHODOLOGY

3.1 Description of Study Area

3.1.1 Agricultural Activities

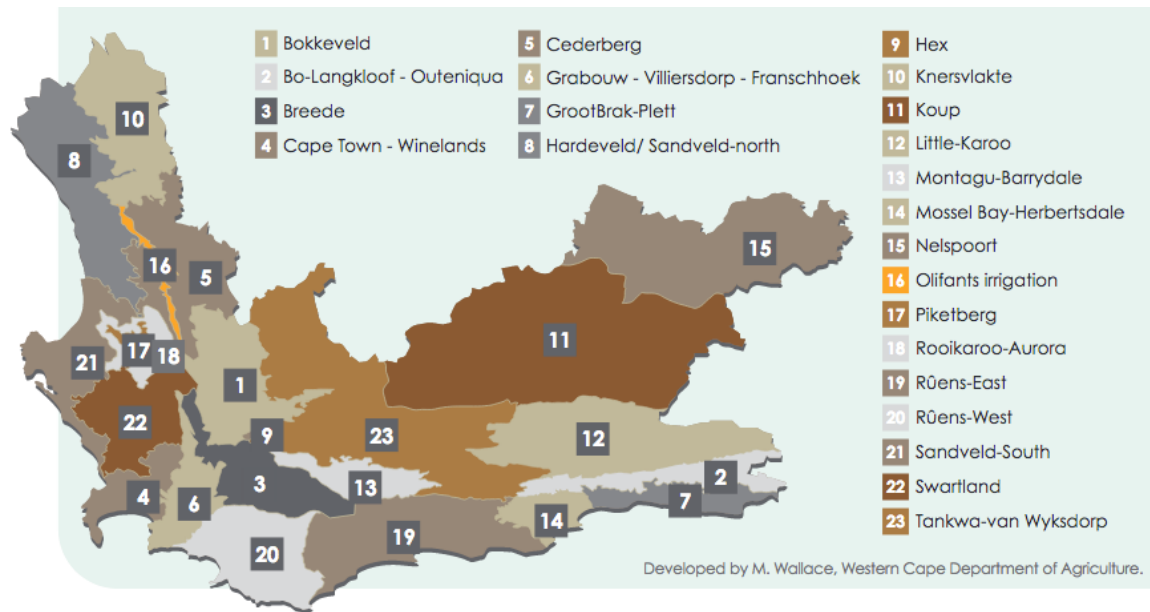


Figure 2: The Western Cape map showing the 23 agro-climatic zones that were targeted by the SmartAgri Plan. Map reproduced from (Wallace, 2015)

This study focuses on the Western Cape province's agricultural sector. Following the diverse topography, climate, and soil types in the Western Cape province, the province is characterized by different agro-climatic zones or relatively homogeneous farming areas (RHFAs) (Theron et al., 2021). Wallace (2015) identified 23 agro-climatic zones in the Western Cape province. As depicted in figure 2 above, these agro-climatic zones have a wide range of land use potential and constraints, thus allowing for various agricultural commodities to be grown in the province (Theron et al., 2021). Due to this, the agricultural sector in the Western Cape is well diversified across subsectors of field crops, horticultural crops, and livestock (WCDoA, 2016a). The sector is composed as follows: grains, oilseeds, and lupines (8%), vegetables (12%), perennial crops (53%), tobacco and teas (1%), livestock (27%) (WCDoA, 2016a). Table 1 below provides a detailed overview of crop and livestock commodities produced in each of the Western Cape agro-climatic zone.

Table 1

Commodities for each of the Western Cape agro-climatic zones. Table reproduced from (WCDa, 2016a).

Area code	Agro climate zone	Main commodities
1	Bokkeveld	Pome fruit, wheat, stone fruit, onions, potatoes, and cattle
2	Bo-Langkloof-Outeniqua	Pome fruit, hops, wheat, stone fruit, flowers, honeybush, Cattle, sheep, goats
3	Breede	Wine and table grapes, wheat, stone fruit, pome fruit, olives, citrus, vegetables, flowers, Broilers, egg laying chickens
4	Cape Town-Winlands	Wine and table grapes, wheat, stone fruit, vegetables, olives, canola, citrus, flowers, berries, Broilers, egg laying chickens, pigs
5	Cederberg	Rooibos, wheat, citrus, wine grapes, stone fruit, vegetables, potatoes, flowers, Cattle
6	Grabouw-Villiersdorp-Franschhoek	Pome fruit, wine grapes, wheat, barley, stone fruit, flowers, berries
7	GrootBrak-Plett	Wheat, barley, vegetables, nuts, berries, flowers, honey bush, Cattle, dairy, egg-laying chickens
8	Hardeveld/ Sandveldnorth	Wheat, wine grapes, rooibos, potatoes, vegetables, Cattle, sheep
9	Hex	Table grapes, citrus
10	Knersvlakte	Wheat, wine, and table grapes, Rooibos, Cattle, goats, sheep

11	Koup	Olives, vegetables and vegetable seed, stone fruit, Cattle, game, goats, sheep
12	Little-Karoo	Wheat, vegetables, wine grapes, stone fruit, olives, nuts, Cattle, dairy, goats, ostriches, pigs, sheep
13	Montagu-Barrydale	Stone fruit, wheat, barley, wine grapes, pome fruit, citrus, olives, flowers, nuts, Sheep
14	MosselBay- Herbertsdale	Wheat, barley, canola, flowers, Cattle, dairy, ostriches, pigs, sheep
15	Teleport	Olives, Cattle, goats, ostriches, sheep
16	Olifants irrigation	Citrus, wheat, wine & table grapes, rooibos, tomatoes, potatoes
17	Piketberg	Pears, fynbos flowers, stone fruit, wheat, citrus, Cattle, sheep herbs/essential oils, wine grapes, Cape rush, rooibos
18	Rooikaroo-Aurora	Wheat, canola, rooibos, table & Wine grapes, potatoes, olives, flower
19	Rûens-east	Wheat, barley, canola, citrus, olives, herbs/essential oils, Cape rush, berries, honeybush
20	Rûens-west	Wheat, barley, canola, wine grapes, pome fruit, flowers, vegetables, olives, citrus, herbs/essential oils, berries
21	Sandveldsouth	Wheat, potatoes, rooibos, canola, citrus, flowers
22	Swartland	Wheat, wine, and table grapes, canola, olives, citrus, vegetables, stone fruit, berries, flowers
23	TankwavanWyksdorp	Wheat, stone fruit, wine & table grapes, vegetables, olives, nuts

The understanding that the Western Cape province's agricultural sector is composed of different agro-climatic zones, as depicted in the map in figure 2, shaped SmartAgri's implementation plan. This is evidenced by the plan's geographically focused and commodity-based approach in developing regional commodity briefs and case studies for the sector. A geographical and commodity-based approach was adopted to ensure the availability of highly localized and context-specific climate change adaptation information for the different farming

categories in the Western Cape (WCDoA, 2016a). Although the SmartAgri plan produced 6 case studies and 16 regional commodity briefs for the different Agro-climatic zones and commodities in the Western Cape province, this research covered only some of the 16 regional commodity briefs and case studies produced. Due to the research's scale and data availability, this research selected only four of the sixteen briefs. These are mainly the [Brief for the Grain and Livestock sector: Swartland and Greater West Coast region](#); [Brief for the Grain and Livestock sector: Rûens](#); [Brief for the Deciduous fruit sector](#) focusing on farmers in the Ceres region and lastly, the [Brief for the Rooibos Sector](#) focusing on farmers in Clanwilliam. These commodities and areas were selected based on their vulnerability to climate change, as shall be covered in the following section. For the second type of communication output (i.e., case studies), this study focused on the [Disaster and Risk Management](#) (DRM) case study as the theme was cross-cutting and broadly relevant to the selected commodity groups and regions.

3.2 Climate change and Impact on the selected agro-climatic zones and commodities

3.2.1 Small Grains in the West Coast and Rûens-east

Small grains, for instance, wheat and barley, are grown primarily in two areas of the Western Cape Province: Swartland and Rûens (Theron, 2021). This study focuses on small grains in the Greater West Coast and the Rûens-east, as depicted in fig 3. The focus on the greater West Coast region is because wheat production decreases from the southern Swartland towards the north because of higher temperatures, lower rainfall, and poorer soils (WCG, 2015); thus, it will be essential to assess how the SmartAgri communication materials are regarded actionable by farmers in these areas. Rûens-east, on the other hand, is a focus because climate steadily changes to year-round rainfall in the east (Rûens-east) due to spatial variability of rainfall across the Rûens region, reducing the possibility for agriculture (Theron, 2021).

With wheat in the Western Cape a rainfed crop, the length of the rainy season is essential for the growing season (Theron, 2021). However, climate modelling studies predict, with a high degree of certainty, continuous warming and decreases in winter rainfall in the western regions of the province by mid-century and beyond. (WCG, 2015). In Rûens-east, variable climate conditions are already limiting wheat production (Midgley et al., 2016). Generally, the Rûens-

east area is subject to periodic droughts, thus, is vulnerable to a moderate level of production risk (Wallace, 2013).

On the other hand, wheat production in the West Coast is susceptible to temperature increases and heat waves, which results in significant heat stress for crops. Davis Vincent (2017) and DEA (2018) argue that increasingly drier winters with less seasonal rainfall, longer dry spells, and an increase in the frequency of flash floods, late springs, and early summer rainfall should be anticipated in the West Coast region and the Rûens-east as the effects of climate change become pronounced. Decreasing seasonal rainfall, especially in the autumn months, is a cause for concern considering that autumn rainfall is crucial for wheat production (Wallace, 2013). Wheat is planted from late autumn (May) to the start of winter (June) (Wallace, 2013). Thus, if sufficient rainfall is not received by the end of autumn, farmers will be compelled to labor within a reduced rainfall season or to forgo planting altogether due to the economic impact (WCG, 2015).

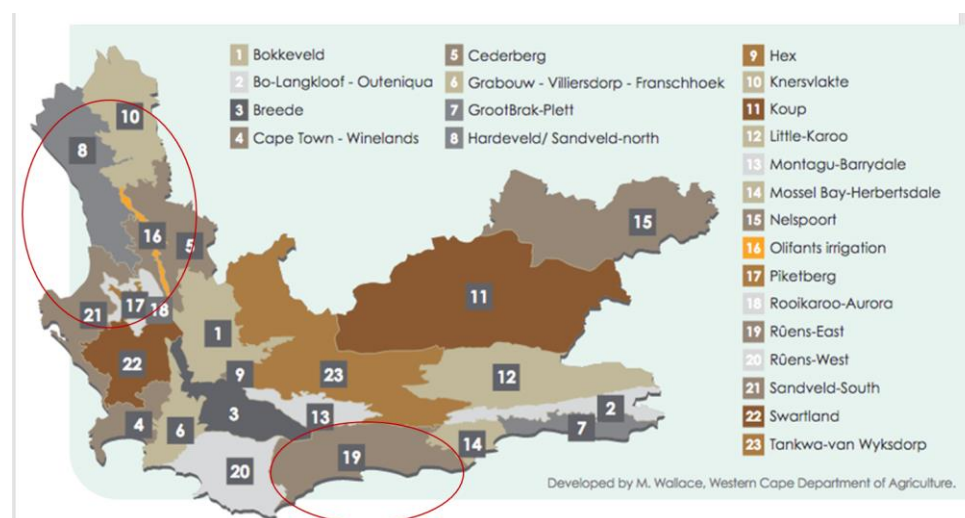


Figure 3. Map of the Western Cape Province highlighting the 23 Agroclimatic zones used in the SmartAgri Plan and the West Coast and Rûens-east region (Circled). Map reproduced from (Wallace, 2015)

3.2.2 Deciduous Fruits in the Ceres Region.

Ceres, located in the Western Cape's Cape Winelands district, is the major deciduous fruit producer in the province. It encompasses three distinct landscapes: the Warm Bokkeveld (a

vast fertile valley in the heart of Ceres), the Bo-Swaarmoed (east of Ceres and famous for its cherries), and the Koue Bokkeveld (in the north, a mountainous region producing fruit and vegetables) (Tharaga, Steyn & Coetzer, 2021). Climate change projections for the Ceres are concerning. Average temperatures for fruit production areas in the Western Cape are expected to increase by 1 to 2 °C above pre-industrial levels (Tharaga, Steyn & Coetzer, 2021). These temperature changes will be followed by low autumn and winter rainfall and a shorter winter season with regards to temperature (New et al., 2006). Deciduous fruits rely on the availability of water and the need for cold winters to fulfil certain chilling requirements (Luedeling & Brown, 2011). Although irrigation systems often support deciduous fruits, the water challenges in the Western Cape leave little room for irrigation expansion. (Archer et al., 2019). Climate change impacts climate metrics such as winter chill units (Tharaga, Steyn & Coetzer, 2021). Increasing temperatures in Ceres will result in potential changes in winter chill units for the Ceres region. Insufficient chilling accumulation during the winter will result in delayed bud break and flowering of the fruits, thus affecting deciduous fruit production. This could have a significant and disastrous financial impact on apple farmers in Ceres. Thus, due to the economic cost of climate change on deciduous fruits, farmers in the Ceres region might have to choose between stopping their production and adapting to new climate conditions (Tharaga, Steyn & Coetzer, 2021).

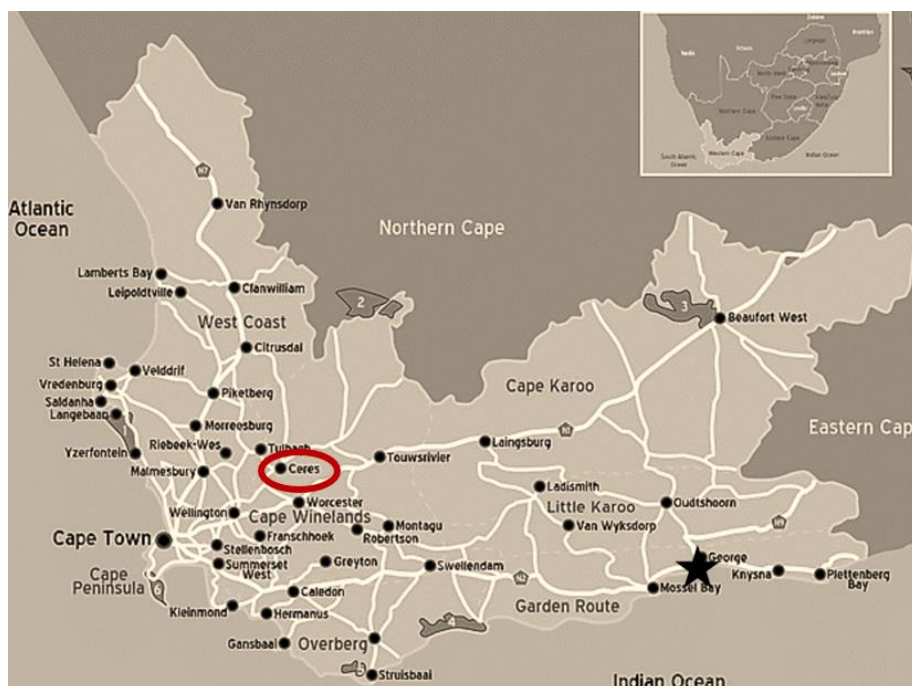


Figure 4 Map of the Western Cape Province showing the Ceres region (Circled)

3.2.3 Rooibos in the Clanwilliam, Cederberg Region.

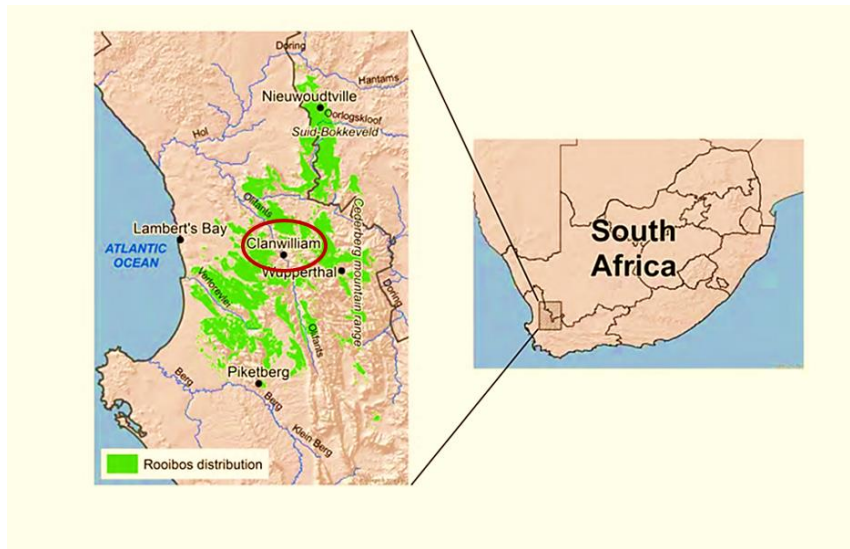


Figure 5 Map of the Western Cape Province showing Clanwilliam (Circled), one of the traditional rooibos-producing areas. Map reproduced from Lotter (2015).

For rooibos, six agro-climatic zones, namely: Rooi Karoo-Aurora, Knersvlakte, Olifants irrigation, Cederberg, Hardeveld-Sandveld North, and Sandveld South, are covered under the SmartAgri plan (WCG, 2015). This study focuses on Clanwilliam, a town in the Cederberg region, as depicted in Fig 5. The Cederberg region is one of the Western Cape's traditional mountainous rooibos growing regions. It is bounded west by the Atlantic Ocean and east by the Cederberg Mountain range. The Berg River and Nieuwoudtville in the Northern Cape Province form its northern and southern boundaries. The Cederberg region is a semi-arid environment with low and erratic rainfall, high evapotranspiration rates, and nutrient-poor soils that limit conventional agricultural production (Cowling et al., 1997; Goldblatt & Manning, 2000). Climate modelling studies in the Cederberg area revealed potentially disastrous changes that include more significant precipitation variability, the potential for longer dry spells, delayed winter rainy seasons, and heavier and late summer rains with higher temperatures. According to recent bioclimatic modelling studies, rooibos production will not change in higher-elevated, traditional rooibos production areas. Considerable decreases are projected in areas in the west along the coast, especially in the lower-lying regions, and an increased frequency of heat waves may be experienced (SmartAgri, 2016; Rooibos Limited, 2018). Given that rooibos is rain-fed, the expected climate predictions will impact the quality of yields (Archer et al., 2008; Malgas et al., 2010). For instance, late winter rains, increases in dry spells,

and heat stress affect crop performance, and reduce yields and the rooibos produce's quality (Archer et al., 2008).

3.3 Research Design

Literature on decision-relevant information suggests that engaging in investigative interactions with prospective users of climate information to understand their decision contexts aids in narrowing the gap between climate research and its application in adaptation (Jagannathan, 2019). To assess how useful the CSL framework is in bridging the information action gap in the Western Cape's agricultural adaptation, this study used a qualitative case study methodology, which allows one to do intensive research on a specific case, i.e. (individuals, groups, institutes, or communities) (Rashid et al., 2019). A qualitative case study approach enables the investigation of a phenomenon in its context using different data sources such as research, documentation, interviews, and observations (Yin, 2009; Gray, 2004; Baxter & Jack, 2008; 2010), allowing essential components, processes, and interactions to be identified (Rashid et al., 2019). Moreover, this approach can demonstrate context effects, thus allowing the researcher to make inferences about a situation (Baxter & Jack, 2008).

A qualitative research approach was chosen because it allowed for an interactive and in-depth examination of respondents' experiences and social realities (Khalil et al., 2020). A significant advantage of a qualitative research approach is that it is not dependent on sample sizes like quantitative methods (Pasquini, 2019). Thus, the primary aim of this study was not the number of participants but how well the participants represented a cross-section of key stakeholders, i.e., users and producers of the climate change adaptation information under examination. Thus, in this regard, different commodity farmers from the different agro-climatic zones in the Western Cape were selected for the study. More so, given the nature of the research objectives, which are "how and why" in nature, a qualitative approach allowed respondents to express their views and perceptions. This was regarding farmers' views and perceptions on the barriers to applying climate change adaptation information in decision-making and their perceptions of the credibility, salience, and legitimacy of the briefs and case study under review. Farmers also provided detail on how the briefs and case study are and/or can be useful for their decision

contexts, the types of knowledge they consider actionable, their information needs, and the engagement processes that can effectively elicit their information needs.

3.4 Target Population and Sampling

The population which was targeted by this study were commercial farmers producing small grains, deciduous fruits, and rooibos. These were identified as users and potential users of the information outputs that were under review, which include: Brief for grain and livestock sector (Great West Coast and Swartland); Brief for grain and livestock sector (Rûens); (brief for deciduous fruits; Brief for the rooibos sector; and lastly, the DRM case study. The study also targeted the information producers, i.e., scientists and/or agricultural experts that were part of the SmartAgri team.

Purposive sampling, also known as judgment sampling, was used to select knowledgeable participants based on their ability to provide in-depth information pertaining to the topic under inquiry (Luborsky & Rubinstein, 1995). A total of four scientists and agricultural experts were chosen based on their roles and responsibilities in the SmartAgri plan and the development of the information outputs under review. In selecting farmers, the SmartAgri plan functionaries linked the researcher with several agricultural experts for different commodity groups, i.e., extensive livestock, wine grapes, small grains, deciduous fruits, and rooibos. From these experts, a list of 40 potential farmers with a wide range of characteristics including agro-climatic zone, commodity specialization and contact details was established. Identified farmers were then brought on board in the following ways: (1) they were contacted through email by the researcher, who then sent invites outlining the study and assessing their readiness to participate. (2) Emails were followed up with telephone calls to ensure informants received the email.

Eleven farmers from three commodity groups i.e., small grains, deciduous fruits, and rooibos, respondent to the email invitation. The initial criterion for selecting farmers was for participants to be producers of any of the commodities under review and for the participants to know the SmartAgri plan and the information outputs produced. However, eight of the respondents were unaware of the plan and the information outputs produced under the plan, an aspect that was beyond the researcher but also posed questions about how the plan was communicated to farmers, thus an aspect which also became an area of interest as part of the study.

The researcher proceeded with these farmers but took important steps to explain the SmartAgri plan and relevant information outputs to the commercial farmers unaware of the Smart Agri plan. Interview dates and times were then discussed and planned with the participants. Participants chose their preferred dates, time, and data collection method, which was generally telephone interviews.

3.5 Data collection methods

The researcher started by collecting data from scientists and agricultural experts to understand better what the project envisaged when they developed the knowledge products and the scientists' and agricultural experts' perceptions of the Credibility, Salience, and Legitimacy of the knowledge products.

An online semi-structured focus group discussion on Zoom, an audio/video conferencing software, was first conducted with the selected SmartAgri scientists and agricultural experts. In terms of disciplinary focus, these scientists and agricultural experts included the Western Cape Department of Agriculture Deputy Director General Agricultural Research and Regulatory Services (DDG: ARRS); the SmartAgri plan manager and the scientist responsible for the development of the plan and communication outputs; a cropping systems specialist and a specialist for the plan's spatial/ GIS unit.

Using a Focus Group Discussion (FGD) in interviews with SmartAgri scientists and agricultural experts was crucial to the study. This is because FGDs can reveal detailed opinions that people hold about a topic, as well as perceptual differences between people (Khalil et al.,2020). Thus, specifically for this study, such dynamics provide an opportunity to compare views and understandings. Furthermore, the social contact between participants frequently results in lively conversations, which can help collect rich and valuable data. However, due to the different participants often involved and group dynamics, FGDs are challenging to organize and manage (Khalil et al.,2020). They may also be inappropriate for investigating sensitive themes that many participants may be uncomfortable discussing in a group context (Khalil et al.,2020).

Afterward, the researcher conducted semi-structured telephone interviews with the eleven commercial farmers to better understand farmers' perceptions of the usability of the briefs and case study in relation to their perceptions of the Credibility, Salience, and Legitimacy of the knowledge. Commercial farmers consisting of four small grains, four deciduous fruits, and three rooibos farmers were selected. The researcher differentiated small grains (SG), rooibos (RF), and deciduous fruits farmers (DFF) to identify potential disparities in farmers' evaluation of the usability of the information outputs under review. According to Soubry et al. (2019), such contextual information improves comprehension of farmers' observations and local "ground" knowledge (Soubry et al., 2019: 8). While the sample size was limited, in-depth discussions with farmers allowed perceptions and reactions to be expressed and contextualized, thus enabling a rich dataset.

Interviews were conducted between October and November 2021. With farmers' limited knowledge of the information outputs prior to the interview, the knowledge products were shared with each interviewee, including a 7-minute presentation on the relevant Brief, and case study was done at the beginning of each interview to ensure farmers understood the subject matter. All interviews were done in English, audio-recorded, and then fully transcribed. The interviews lasted 45 minutes on average, ranging from 30 minutes to 1 hour. Both the FGD and the telephone interviews were done with the assistance of an FGD and interview guide (see Appendix 4 and 5).

The FGD guide for scientists and agricultural experts was designed to elicit information on what the SmartAgri plan envisaged when they developed the knowledge outputs, scientists and agricultural experts' perceptions of the Credibility, Salience, and Legitimacy of the knowledge outputs. The interview guide for farmers, on the other hand, was designed to elicit an open discussion on their awareness of SmartAgri plan and the briefs and DRR case study produced under the plan, their access to and use of climate change adaptation information, including possible barriers, their perceived credibility, salience, and legitimacy of this knowledge, as well as their information needs.

The interview guide was followed loosely, enabling the dialogue to be directed partly by the interviewees' cognitive processes. This approach is critical because it allows the debate to move beyond simplistic binary choices (e.g., used/did not use, trust/did not trust), eliciting a more qualified understanding of the significance of predictive information in management decisions

(such as how, why, and to what extent) (Hayman et al., 2007). The FDG and interview guide were composed of open-ended questions. Open-ended questions facilitated the elicitation of narratives and allowed unexpected relevant issues and insights to emerge naturally (Barriball & While, 1994). Appendix 1 shows the full interview guide.

Virtual means of data collection were employed in this study considering the ongoing Covid-19 pandemic and national Covid-19 management guidelines, which continue to emphasize physical distancing and limited gatherings (WHO, 2020), thus limiting the feasibility of face-to-face interviews. UCT also had strict rules in place concerning field research to manage the risk of spreading the pandemic. All in-person research was prohibited during the fieldwork period. With this background, virtual data collection methods provided an alternative option to one-on-one interviews. The significant advantage of virtual data collection methods is that they enable real-time communication between two or more people located in different places (Gough & Rosenfeld, 2006). As a result, practical obstacles like geography and distance that can make it difficult for the researcher and participants to interact in person are eliminated. (Deakin & Wakefield, 2013).

However, a significant challenge with virtual data collection methods is that virtual data collection methods may restrict participation to only those with access to web-enabled devices. For instance, online video platforms require a strong internet connection and considerable data usage. People with limited access or without access to reliable internet may find participating challenging or less appealing. Moreover, participants who feel they need to be more proficient in using online technology may be excluded or face additional burdens and significant stress if online data collection methods are employed. However, consulting participants on technological and logistical choices is crucial to mitigate these challenges. Video conferencing platforms may be inappropriate for persons with limited access to technology; inclusion may need interviewing without video (audio only) or through telephone to avoid the need for internet.

Initially, the study planned to have Zoom online focus group discussions with farmers. However, this was a challenge to organize due to farmers' busy schedules and weak internet connection. Thus, the option for telephone interviews was viable, and it still allowed rich data to be collected. The primary benefits of telephone interviews include convenience, where telephone interviews allow access to participants who would otherwise be difficult to reach

(Fenig et al.,1993). This was very important considering farmers' connectivity challenges and busy schedules. According to Fenig et al. (1993), when busy, it is often easier to schedule a phone call than to meet face-to-face or online. Thus, telephone interviews enhanced farmers' disposition towards participation in the research. In addition, telephone interviews offered greater flexibility and convenience for farmers to set up appointments on the days and times that were most suitable for them. Cachia & Millward (2011) also noted this as one of the significant advantages of telephone interviews. Telephone interviews also allow notetaking by the interviewer, which can be a significant distraction in physical interviews (Sturges & Hanrahan, 2004).

Nevertheless, although telephone interviews are generally cost-effective because of lack of travel costs, the mobile phone call costs added up, considering that the calls were lengthy. Furthermore, the ability to reschedule influences the time the actual interviews are held (Cachia & Millward, 2011). Nevertheless, telephone interviews remain a better alternative and contingency plan compared to face-to-face interviews, which were not viable in this case (Cachia & Millward, 2011)

3.6 Data Analysis

Interviews were transcribed and imported into NVivo and coded using a content analysis approach. Coding was done manually by labeling related data into various category codes. A codebook based on emergent questions of a priori interest (i.e., perceptions of Credibility, Salience, and Legitimacy for both producers and users) was developed. This coding technique allows the participant's exact words to be captured and organized for analysis. The software retrieved all quotes associated with the given topic (i.e., credibility). Once gathered, the researcher then performed thematic analysis on the data set where "emphasis was placed on the content of the text, i.e., what is being said" (Reissman, 2005: 2) to unpack the components of the conceptual framework. Thematic analysis is a technique for identifying, examining, and reporting patterns or themes in data (Braun & Clarke, 2006: 79). The themes representing participants' experiences are then compiled and systematically compared between transcripts. The data sets were analyzed by the researcher to find higher-order themes. The researcher compared small grains, deciduous, and rooibos farmers' perspectives on both a priori subjects and those that emerged to identify commonalities and variations among groups (i.e., among all

commercial farmers) as well as between commodity groups and agroclimatic zones. The categories, topics, and comparisons were examined, discussed with the research supervisors, and revised as necessary to guarantee rigor and quality.

3.7 Limitations

Although research participants found virtual interviews convenient (Deakin & Wakefield, 2013), building rapport with participants virtually was a challenge. According to Deakin & Wakefield (2013), creating and maintaining rapport with participants through conferencing is different from face-to-face interviews. The absence of physical interactions and visual cues can hinder the crucial rapport-building process (Cachia & Millward, 2011). Gray et al. (2020), however, contend that the researcher's personality and level of comfort with technology can, to a greater extent, influence the ability to build rapport with participants.

Reluctance by farmers to participate was also another challenge. According to Deakin & Wakefield, (2013), this is a common problem especially in virtual data collection methods where there might be issues of mistrust, lack of perceived benefit, or perceived burden (Deakin & Wakefield, 2013). Concerning this study, farmers' unwillingness to participate in the interviews was mainly due to farmers work commitments and busy schedules. Moreover, with the COVID 19 pandemic which affected everyone worldwide, participating in a study was not a priority for most farmers who were contacted. This affected the number of participants that could have been engaged in a normal environment.

Switching from the initial plan of FGDs online to telephone interviews helped the challenge. Telephone interviews proved effective as they provided convenience to participants who were not comfortable with online interviews and those that were difficult to reach. Nevertheless, by replacing FGDs with telephone interviews, the researcher missed out on the benefits of the group context, which provides insight into social relations and the overlapping nature of knowledge, something those individual narrative interviews need to have strength in.

3.8 Ethical Considerations.

Ethical considerations entail collecting data with special care not to harm participants, contravene their rights, or leave any negative legacies (Brittain et al., 2020). With this study involving interaction with various participants, the researcher diligently observed certain ethical considerations. The study was guided by the University of Cape Town's Faculty of Science Research Ethics Committee (UCT-FSREC), whose guidance and clearance was obtained before data collection. Before each interview, all respondents were informed about the study's aim and the interview process through email communication. Their consent to participate in the research was also obtained in writing through emails. Data was collected virtually to observe COVID-19 restrictions and to avoid any potential harm to key informants. The research also ensured participant confidentiality and identity protection by avoiding using names and contact details in the final report. Code names such as SG01 for small grain farmers, RF01 for a rooibos farmer, and DFF01 for a deciduous fruit farmer were used instead. Lastly, with clearance from UCT-FSREC, all interviews were audio recorded solely for data analysis purposes, where the interview files were later transcribed and analysed using qualitative techniques.

CHAPTER 4: RESULTS & ANALYSIS

4.1 Introduction

The main objective of this study was to examine the usefulness of the CSL framework in bridging the potential disconnect between information production and its use in climate change decision-making by farmers in the Western Cape, South Africa. To actualise the research aim as guided by the study's specific research objectives, primary research data was collected from scientists and agricultural experts as well as commercial farmers. From the scientists and agricultural experts, the study utilised an online focus group discussion to solicit their views and opinions on the matters the study inquired about. Commercial farmers' primary data was collected from the producers of small grains, deciduous fruits, and rooibos by way of semi-structured telephone interviews. This chapter, therefore, presents and discusses the findings that arose from the researcher's interactions with the respondents. The research findings were presented and discussed in accordance with the research objectives.

4.2 CSL-related factors that hinder the use of climate change adaptation information

The study inquired into the factors that hindered farmers' use of climate change adaptation information in decision-making. In the context of this inquiry, the study found that 70% of farmers interviewed were unaware of the information outputs under review or the SmartAgri plan. However, these farmers attested to having seen and heard much information on agricultural climate change adaptation through emails and radio. A large portion of the farmers, however, noted that they do not usually engage with such content. With this, the study sought to establish what accounted for the limited engagement with climate change adaptation information. The sections below present and discuss the findings in this regard.

4.2.1 Financial Challenges

Farmers identified access to financial capital as a significant obstacle to their acceptance of knowledge on climate change adaptation. Farmers claim that even while the plan provided them with crucial information, adapting to climate change necessitates changes to several parts

of their farm operations, all of which need a sizable amount of financial resources. Farmers observed the glaring absence of infrastructure supporting farmers in that area, for instance, loans for machinery investment. They stated that a farmer's passivity could result from being unable to invest in new farming technologies due to a lack of sufficient financial resources. This is evident from one of the farmers' comments.

I have a neighbor who farms right next to me. Since he is surrounded by other farmers, he can see that the soils around him are better due to neighbouring farmers who are implementing different practices to improve soil and productivity, but he doesn't apply those climate change adaptation practices. The constraining power for him is access to financial capital. You need to have lots of money to upgrade to those efficient machines It is a tough thing to do if you are still set up like the 1980s and 1990s (SG01)

Several respondents, especially small grain farmers, noted the same challenge and expressed a need to move beyond climate change sensitization and awareness raising towards linking farmers with finance mechanisms needed to invest in new machinery for climate change adaptation, for instance, investment of climate resilient cultivators that reduce soil tillage and improving wheat yields (Shew et al., 2020). This finding is in line with Carr et al. (2020), who argue that financial challenges are some of the key barriers to implementing climate change adaptation information by farmers.

4.2.2 Lack of Experiential Knowledge

Farmers also identified the lack of practical experience as a significant impediment to applying to implementing climate change adaptation information. The respondents assert that since farming is a practical industry, all knowledge must be informed more by experience than pure scientific theory. This is best demonstrated by the following deciduous fruit farmers' comments:

You see the problem is that scientists have zero practical experience. Scientists can tell you that fertiliser is good, but a farmer on the ground can tell you about the

quantities and costs etc. So, I would rather go to someone who has done it and is successful rather than relying on theory (DF02)

One farmer made the case that scientists should work with farmers to test scientific information and interventions to give farmers the confidence to use the knowledge. Scholars such as Ingram et al. (2016), who contend that farmers frequently act on their gut feeling rather than reason and are more receptive to solutions that have already been tried by other farmers, broadly endorse this viewpoint. Providing real-life experiences becomes more crucial when developing decision-support tools, (Ingram et al., 2016).

4.2.3 Rigidity

Farmers must be highly agile to adapt to climate change, and this agility reveals itself in their readiness to give up conventional farming methods and adopt new ones. Farmers expressed their belief in the methods and practices they already use on their farms. Farmers stated that even if adaptation to climate change is necessary, they can still survive its effects by continuing to use their current methods. This demonstrates their inertia to change. Despite of climate change effects on their operations, some of the respondents were quick to point out that they would prefer to stick with what they had already implemented over the years based on their wealth of knowledge and experience because it was working for them, and their financial returns were guaranteed. The findings, therefore, revealed that there existed a degree of rigidity on the part of the farmers which is bound to result in inertia. This finding concurs with Singh et al. (2017), who argue that the use of information by the farmers on climate change adaptation is hindered farmers' unwillingness to immediately try out something new without proper evidence of effectiveness.

4.2.4 Relevance of Information to farmers' information needs

Most farmers who were interviewed pointed to the concern of relevance as a significant obstacle to utilising climate change adaptation information. In the comment following, this is made plain.

I must be selective about what I pay attention to because I get more than 20 emails per day. I will immediately unsubscribe if you send me a case study about a man who is planting almond trees to cope with climate change or anything else general about climate change because it has nothing to do with what I do. We know providing relevant information is challenging because everyone's relevance varies. For example, I grow wheat, barley, and canola, but 20 kilometers away is a dairy farmer, and 10 kilometers away from him is a citrus farmer. However, it does capture your attention if something you specialise in is being talked about rather than just hearing broad concepts about climate change (SG01)

This finding speaks to the importance of Salience i.e., the usability and appeal of the information to users' needs. In this case, the study found that most of the information not used in decision-making is because it falls short of relevance to farmers' decision-making contexts. This finding is comparable to Jones et al. (2017) and Fleming and Vanclay (2011), who all highlighted that if the information is perceived to be disconnected from users' information needs, such information is regarded as not usable by users.

4.2.5 Access to information

Access to information was also highlighted in the interviews as one of the key impediments to using climate change adaptation information in decision-making and farming operations. For instance, 70% of farmers interviewed highlighted that they did not know the case study or regional commodity briefs. About 10% of the farmers had challenges in distinguishing SmartAgri from other climate change adaptation activities being conducted in their regions. All this speaks to information access. Whilst the lack of access by the farmers in this regard does not mean that the information was not made available to them through various channels, it suggests that the channels could have been more extensive in their reach. The packaging of the information was inconsistent with the preferences of the commodity producers. For instance, farmers noted that the primary means by which most climate change adaptation information is being made available is through formal government websites and mass media (radio and television). Farmers noted challenges related to delays in getting that information to the grassroots level. Guido et al. (2019) argue that only information that has been accessed

becomes available for use. Fleming and Vanclay (2011) also concur and attest that limited access to the information is a significant barrier to utilising it in decision-making.

4.3 Information Producers' Perceptions of Case Study and Briefs being CSL for uptake

In the engagements with the information producers who were the key informants to this study, the research inquired into their perceptions regarding the information they produced (the DRM case study and the regional commodity briefs). The study, therefore, sought to deduce the extent to which the information producers perceived their information outputs as Credible, Salient, and Legitimate for uptake by the commodity producers for whom the information was also targeted.

4.3.1 Credibility

The key informants who were interviewed in this study revealed that the regional commodity briefs and the DRM case study were highly credible. In their view, the information produced was credible on all levels, from the sources that were used, the process, and the content that was developed as reflected in the text verbatim below:

For all of them (Regional commodity briefs), I would give them the highest reliability because the information in there is based on a status quo review we did on the Western Cape's climate and agriculture. This review was conducted in a scientific manner, the same way you would with any scientific review, and you could publish that information. It is based on published literature, up to the end of 2015, which was the latest scientific knowledge at that time. (Key Informant 1)

In this regard, Credibility is defined based on science. As per the text verbatim from Key Informant 1, the regional commodity briefs were highly credible as they were produced following extensive scientific research and was based on what was known about climate change and its implications on the various commodities at the time of research and compilation.

For the DRM case study, the key informants noted that the preparation of the case study was based on extensive consultation and engagements of academic experts and experts in practice. Moreover, the case study was developed based on findings from long-term trials, as was noted below.

Much knowledge in our case studies is based on the long-term trials that we are running, with the oldest one currently in its 25th year, so there is a lot of knowledge and information that has been collected over time that is informing the case studies we are producing. (Key informant 2)

In this regard, the perception is that the case study was highly credible based on the amount of research and experts that were involved in the production of the case study. This demonstrates that sources and processes used to generate and deliver climate change adaptation information remains an important determinant of Credibility. The finding agrees with Ingram et al. (2016), who argued that one of the measures of Credibility is the rigour, rationality, and systematic approach adopted in the process of producing the information.

With information uncertainty, a key factor affecting perceptions of information credibility (Nissan et al., 2019), interviews with key informants also assessed how information uncertainties were managed in the production of the information outputs. This was mainly for climate projections, and future land uses. Key informants noted that information uncertainties were dealt with in a scientific manner. For climate projections, information uncertainties were addressed the same way that IPCC addresses them, by looking at probabilities and analysing agreements and disagreements between studies. In addition, respondents noted that different sources of information were used to ensure credible information was being provided to users. Where there were clear uncertainties, the uncertainties were communicated with farmers "We told farmers what we knew with a high level of certainty and what we were unsure of we also communicated" (Key informant 1). The key informant gave an example of rainfall projections in the Western Cape, where they made it clear to farmers that they were uncertainties and farmers in the Western Cape should expect wetting or drying. According to the respondents, communicating uncertainties is good practice as it dispels unrealistic expectations about certainty to the information and improves perceptions of credibility.

4.3.2 Salience

Interviews with the information producers revealed that the aim of developing the case study and the regional commodity briefs was not to meet farmers at their specific point of information needs but rather to raise awareness on the climate change risks on the provinces' agricultural sector. Although there was an attempt to provide responses that farmers can employ to adapt to climate change, this was not done in greater detail, according to the key informants. In this regard, the key informants were alive to the fact that their information outputs fell short of being salient and, therefore, could be regarded as not being fully salient to the specific needs of the commodity producers. This view is reinforced by the text verbatim below:

Let me highlight that the information outputs, especially the briefs, were not conceptualized to meet farmers' information needs. If that had been the purpose, I think they would have been put together differently. (Key informant 1)

Salience addresses issues of relevance of the information to the needs of the user (Clark et al., 2016). Thus, from this excerpt, one can argue, therefore, that because the information was produced to raise awareness on climate change and its impacts on agriculture, ignoring farmers' specific contextual needs, it fell short on that score of Salience.

However, a few insights from the respondents and a reading of the briefs brings a new dimension to the argument around Salience and utility of the case study and the briefs. The commodity briefs, to some extent addressed certain issues pertinent to farmers. Apart from raising awareness on the impact of climate change on the various commodities in the Western Cape, this information was made context-specific through providing risks by commodity and agro-climatic zone. The briefs were alive to the Western Cape's diversity in topography, climate, and soil types. This is clear from the verbatim below by two of the key informants:

The briefs' set the scene and provided agricultural stakeholders with a scientific background of the risks and what science is saying about their different regions and commodities. (Key informant 1)

The case studies, on the other hand, communicated the different climate change adaptation and mitigation exit points and project priority areas to stakeholders. Looking specifically at the DRM case study, it showcased successfully implemented DRM projects in different contexts, e.g, disaster risk management in urban and peri-urban areas. (Key informant 2)

With this, it can be argued, therefore, that the briefs and the case study were partially salient because although they were not produced to address farmers' specific information needs, they were able to indirectly address some of the key issues relevant to farmers, which is the availability of localised content.

Access is also a critical component of Salience where if proper channels of information dissemination are not used, users may not utilise the information (Guido et al., 2019). Thus, in this regard, the key informants noted that the plan made efforts to communicate climate change adaptation information with farmers, and this information was always timely to ensure that it was salient to farmers. The key informants noted that the briefs and case studies were made available through a central website, the GreenAgri portal, which is the SmartAgri plan's primary channel for delivering climate change adaptation information to agricultural stakeholders. Mass media (radio and newsletters) was also utilised where in the first two years of implementation, a total of 104 programs on climate change and the Western Cape's agricultural sector were conducted on RSG Landbou, an Afrikaans radio channel in the Western Cape. The plan was also sending out monthly newsletters through the AgriProbe newsletter, a Western Cape quarterly magazine on agriculture. In addition, SmartAgri utilised print media where the briefs and case study were printed and distributed to agricultural stakeholders. According to the respondents, there was much communication in the first two years of implementation because "new science comes through all the time, so we did much of our communication efforts in the first two years to keep up with the latest science" (Key Informant 1). Keeping up with science ensured that the information produced was both credible and salient to farmers according to the key informants

4.3.3 Legitimacy

As noted in the study, the legitimacy of climate change adaptation information is closely tied to the legitimacy of the processes and knowledge that go into producing it. Legitimate processes for knowledge development should attempt to incorporate relevant stakeholders and be perceived as inclusive, fair and transparent. SmartAgri respondents highlighted several factors connected to the design and implementation of the SmartAgri plan, which they felt had ensured Legitimacy of the knowledge development process. According to the respondents, the status quo review that informed these information outputs was accompanied with extensive stakeholder consultations where after the first phase of developing the report, two high-level workshops with stakeholders were conducted in the second phase of the plan. According to the respondents, the first workshop was done with key senior management and decision-makers from various organisations in the Western Cape's agricultural sector, including government and value chain players in the private sector. The second workshop followed in various districts with stakeholders that targeted farmers (commercial and smallholder), extension workers, and key agribusinesses in the Western Cape. Moreover, according to the respondents, the stakeholder engagements took a multisector approach by including other sectors, including water and biodiversity. The respondents considered these engagements a strength as the dialogue with crucial agriculture sector stakeholders provided an opportunity to determine whether the conclusions of the status quo review were useful to the farming communities. These consultations also provided an ample opportunity to fine tune priority responses and actions, said the respondents.

However, the respondents highlighted low participation by farmers during the engagements. According to the respondents, though there was farmer representation during those engagements, some meetings had no farmer attendance. More so when asked if farmers had input in the actual briefs and case studies, the respondents noted that the knowledge outputs were developed by scientists and experts in practice without farmers' input. The limited involvement of farmers has some limitations. However, according to the respondents, most stakeholders in the meetings are usually highly accustomed to farmers' practices and contexts. Therefore, there was enough agreement among the respondents that the process had been thorough and fair in terms of the range of opinions that were consulted. This observation is thus in line with the findings of Guido et al. (2019), who argued that Legitimacy is an expression of the degree of stakeholder participation in the information production processes. In this regard, the fact that the case study and the commodity briefs were a result of extensive

stakeholder engagement means that there was indeed stakeholder participation, and thus, Legitimacy can be inferred.

4.4 Farmers' Perceptions of the Case studies and Regional Commodity Briefs

The study also aimed to understand farmers' perceptions regarding the case study and the regional commodity briefs. This inquiry was important to this study because it gave the researcher insight into the perceived utility of the information produced. While scientist and agricultural experts' perceptions of the Credibility, Salience, and Legitimacy of the developed information outputs were sought, there was a need to investigate farmers' perceptions of the same. This was done to assess similarities and differences in the perceptions of producers and users of information.

4.4.1 Credibility

The findings, as they relate to the farmers' perceptions on the credibility of the information from the case study and the regional briefs reveal that the farmers perceived the information to be credible. The farmers assessed the credibility of the information based on the validity of the information, process credibility, and content credibility.

I rate the information very reliable because it was obviously written by academics. It shows that research has been done and the figures were there, it was nicely written, not too scientific or too intellectual. (DF 01)

My own experience is that in all the years that I have lived on this farm, I think it is getting hotter, and it has been confirmed in one of your briefs that the later part of the summer had become hotter than 50 years ago when I was a child on this farm. (DF04)

It was well stated that this is the West Coast, this is the Swartland and whoever wrote it, gave a very good summary of the type soils we have for example in my farm compared to the type soils in Cape town or down in Caledon or in the Rûens. They showed the differences and that makes the information credible because it

shows that someone has really been here and has looked and analysed the areas (SG02)

In all the cases above, deciduous fruit farmer (DF 01) and (DF 04) as well as the small grain farmer (SG02), all agreed that the information in the case study and the regional briefs was credible. Their perception was premised on the scientific nature of the information and the accuracy of the information based on what was obtaining on the ground. The information, according to the respondents, reflected the local climatology in their different regions including some of the already lived climate impacts that were being experienced on the ground, as shown in the excerpt above by (SG02). According to Ingram et al. (2016), information is credible if the users of the information perceive the information as being accurate, valid, and of good quality.

The interviewees also revealed that the information from the case studies and the regional briefs was devoid of uncertainties which again validates the argument that they held the perception that the information was credible.

There were no uncertainties with the information because the information confirms what we are experiencing in our area. (DFF04)

I believe in the model, I believe we have major challenges in terms of global warming I believe we will have an increase in droughts, erratic rainfall events and as a result, we will have a decrease in production. (RF01)

From the excerpts above, it is evident in the responses that the commodity producers regarded the information to be credible both in terms of its content and since they could not associate the information with any level of uncertainty. In their view, the information was believable, and no doubt was cast regarding the quality and accuracy of the information. This application of certainty as a measure of Credibility is consistent with Kirchhoff et al. (2013a), who argued that in assessing Credibility, the farmers' perceptions regarding the certainty of accuracy of the information is key.

However, some farmers felt that the credibility of the briefs was, to some extent, affected by the inability of science to project long-term rainfall patterns with certainty, as well as the inherent uncertainties associated with long-term climate projections.

I found the temperature projections quite useful, but there were uncertainties with rainfall projections. I know these things are difficult to predict, but it will be good to know with certainty the rainfall projections (SG02)

It is not that scientific information is irrelevant, but it is sometimes not sure about some of these things, and it changes over time. For instance, what science told us 30, 40, or 50 years ago is different from what is saying now so to just go bluntly and act on what science tells us now, it might be detrimental to one's sustainability Someone must take a huge leap or big risk first if there is a big technological breakthrough on how to do things. (RF 02)

From the excerpts above, although the general feeling from farmers was that the information was credible especially regarding the briefs, this credibility was to some extent affected by the briefs' failure to project with conviction important climate indicators like rainfall patterns. There was a general perception among these farmers that scientists themselves do not yet fully understand the environmental system to give farmers the confidence in climate projections. One farmer noted that the fact that there is uncertainty among scientists on rainfall projections shows that science itself is not even sure. Fleming and Vanclay (2011) argue that uncertainty can challenge the authority of climate science and justify inaction. This farmer went on to suggest the need for scientists to prioritise understanding the environmental system especially for key climate indicators like rainfall patterns and how these indicators will change in the future. In his view, this understanding would provide a good foundation on which to build a credible message about adaptation practices.

However, in-depth discussions with farmers showed that uncertainties for longer-term projections, as was the focus of the briefs, are tolerable. According to one deciduous fruit farmer, farmers are cognisance of the fact that complete certainty may not be probable in the long-term. However, he argued that it is always good to know the uncertainties than not knowing at all. The case is, however, different with short-term climate information

I make decisions and plans on such information, and if it is not fully accurate it will affect my business decisions because the margin of error is very small in my line of business (DFF01)

Although there were no short-term climate projections in the briefs and case study, farmers expressed the need for short-term climate information to be provided with much certainty, as uncertainties can result in devastating losses for farmers.

Farmers also emphasized the importance of experiential evidence in increasing the credibility of climate change adaptation information. According to farmers, evidence of farmers who are implementing climate change adaptation approaches was missing, especially in the DRM case study, where such information could have been profiled. While scientists and agricultural experts look more for scientific validation for evidence, farmers noted that they look for both scientific robustness as well as evidence where the approaches have been implemented. According to one rooibos farmer, not all farmers understand scientific information. Farmers prefer to look to their own practices and those of other farmers for validation. In general, farmers noted that it is difficult to convince farmers to adopt new practices without allowing them to learn from others. Farmers need proof that certain changes will increase production or result in other benefits regarding savings, noted one farmer. One farmer suggested that scientists continue increasing trials and demonstrations with farmers, presenting the benefits of certain climate change adaptation interventions to farmers. For instance, demonstrating benefits of practices such as inter-cropping or rotational systems. He argued that such practices would reinforce the credibility of climate change adaptation practices. This can be illustrated in his comment below

There is no question about the reliability of the two documents. However, to have some demonstrations together with farmers would be helpful. I was involved in a long-term trial near Moorreesburg in the 1980s where scientists were trying to convince farmers to change the system of producing wheat in a monoculture system. They were only able to make inroads with the new thoughts when they were able to make demonstrations to farmers. They basically divided a 20-hectare farm into small farms of 1 hectare each and played around with different rotational systems so each year during farmer days they could now show farmers that this field produced 4 tons of grain and that field 2 tons. That way, farmers became

interested in what caused the difference and then when they were told that it is rotational systems which was the difference, they were interested. So, in this case the proposed solutions by this plan, though good they, will remain on paper, but demonstrations can help. (SG04).

From the excerpt above, empirically observing and validating climate change adaptation knowledge in practice is critical in enhancing perceptions of credibility and actual usability in climate change decision-making. This is supported by West et al. (2018), who argue that "ground-truthing" climate change adaptation information is crucial. Trusting new climate change adaptation information is often based on the ability to personally see its outcomes, rather than depending solely on the advice of science (West et al., 2018).

4.4.2 Salience

In terms of the salience of the information contained within the case study and the regional briefs, farmers had different perceptions regarding the salience of the information based on the commodities they specialise in and their agroclimatic zones. While almost all farmers agreed that the briefs gave them perspective about the climate changes that are taking place and impacts on their commodities, some farmers were of the view that the impacts projected in the case studies and regional briefs were not going to have much impact to their farming activities considering the unique nature of their agro-climatic zones. The text verbatim below illustrates this point:

I didn't read the brief or the case study and feel I should change my practices because of climate change. I read the case studies and thought the risk highlighted would still be able to be mitigated in my own business as it is now, I would only make a couple of small changes. But I wouldn't pivot from one business to the other, for instance, stop producing wheat to produce something more resilient because of the area I am in. They mentioned about changing the sheep breeds to those that are more resilient to drought. They also mentioned the likelihood of so many pests in the Rûens etc. Well, I found that not so relevant for us farmers in the West. However, if I were a farmer towards the east, where it is a lot more marginal, I would be giving much attention to those recommendations because there are in the

marginal areas where it is about survival and not just about improving their stance on CC but about making money and being sustainable in terms of running their operations. (SG01)

This was also the general sentiment from a small grain farmer in the West Coast (SG01) who felt impacts could be managed there as they have the advantage of the breeze from the sea which cools off their crops in summer unlike farmers in the Swartland whom he argued could use the information more as they get what he called a "Baari wind", (SG03) which is a warm scorching type of wind which destroys the grain. Although responses from small grain producers SG01 and SG03 revealed that the impacts highlighted in the commodity briefs and the case study were not going to be detrimental to their agroclimatic zones, from their responses, it can be deduced that there was a degree of salience in the information on the basis that SG03 indicated that a commodity producer in the Rûens East and Swartland could find the information of value given their areas which are drier and more susceptible to heatwaves.

The briefs were also questioned in terms of the economic viability of the proposed measures. Some farmers felt that much emphasis was placed on the meteorological aspects and risks of climate change, with key issues on finance mechanisms being disregarded, as illustrated in the verbatim below

It is not just about dealing with the issue of climate change but also dealing with the cost and the physical amount of money you must put into your farming. I did not see much of that. There was more on the scientific, the empirical and meteorological aspects, but the financial implications of climate change were not addressed. Climate change has financial consequences. Of course, they talk about the money that was lost by the sector during the drought but how do we finance these recommendations and avoid those financial losses if there should be high stress situations in terms of climate. (SG02)

Scientists have proved that there is climate change, and we need to do something about it but what I don't know is, whether I should go and get a huge bank overdraft, or will I get help from the government I don't know what I have to do about it. In other Western countries, farmers are being assisted and not left to dry on their own with these costs (DF 03)

Almost all the farmers interviewed felt the briefs totally ignored that important information on financing of climate change adaptation projects and that made the reports not fully salient to them. Moreover, according to farmers, in the briefs and case study, there is no financial or policy incentive for farmers to consider climate change adaptation practices; therefore, a challenge for farmers to act on the information. According to one deciduous fruit farmer, DF03, the challenge is that everything is always left to the farmer to deal with, with no consideration of the burden that farmers already have. For instance, he argued that in 2020, minimum wages in agriculture were pushed up by 16%. While he argued that this is good for farmworkers, it is a cost that leaves little room for farmers to experiment with the measures proposed in the briefs. This was supported by a small grain farmer SG02 who argued that fertilizer input costs for small grains increased by 30% in 2021. Farmers, therefore, argued for a need to consider all those issues and provide farmers with financing mechanisms. According to Kirchoff et al. (2013a), scientific information is used in a broader decision-making context where economic viability is crucial. Thus, proving the economic viability of practices is paramount to enhancing salience of information.

Farmers also argued that the briefs could have been more varied in salience as they left out key issues related to the farmers' top challenges. For instance, issues related to water rights and governance. According to farmers, managing challenges associated with water use conflict is the foundation for reducing farmers' vulnerability to climate change and improving their well-being. They argued that this should have been one of the priority actions in the brief. This can be shown in the excerpts below

Those reports did not even touch on this topic. One of the main ways to mitigate against drought will be ensuring that everybody is using their equitable share and that people are not using what they are not entitled to. Secondly, allowing people to build their own dams for those who can, will greatly improve farmers' resilience to drought. This is the information we want to hear more about, but with the state of the Department of Water Affairs, it will be impossible to get anything out of them (DFF04)

What your brief tells me through your projections is that one needs to be clever about how they preserve water but what it does not tell me is what government is

doing about that. The government needs to allow people to build dams and store water. I could easily build 5 -6 dams, but I cannot do it as there is so much red tape. (DFF 02)

With this, there was a general perception that the SmartAgri plan took a very narrow sectoral approach in addressing the Western Cape's agricultural adaptation to climate change as it excluded key sectors and ignored farmers' development priorities such as water use conflicts and the linkages between these issues and reducing farmers vulnerability to climate change. General findings indicate a need to take a more comprehensive livelihood focus when providing climate change adaptation information. Without major investments towards basic local development challenges, farmers argued that it will be difficult to see how farmers can apply climate change adaptation information to reduce their vulnerability to climate change.

Further, the findings revealed significant differences amongst the commodity producers where some farmers found value in the long-term climate projections contained in the briefs, and others did not. This is captured in the verbatim below from different commodity groups.

So, your long weather predictions, it is important to look at those things to take into context what you might do or not do in the future. However, I am not going to have sleepless nights about the gradual climate change, I mean one can have so many small bumps in between, like you can have a week of 30 degrees temperature that can destroy your entire crop. Planning for something that is going to happen in the next 50 years is not something that I really stress about because it is not going to affect me in the short term (SG04)

Long-term projections are extremely important to know if well presented with enough detail. For example, knowing that this area will warm to a point where chilling will drop to below 800 chilling degrees means do not plant a fruit variety or an orchard because when you plant an orchard, it is going to be there for the next 50 years. So, with this information, planting something now which is borderline means it is not going to be sustainable (DF04)

The long-term climate projections are helpful because with rooibos, plants take about 18 months to go from seedling to harvesting, and you continue harvesting

from that same plant every summer for the next five years; thus, information on how climate will change in the next five-ten years will be helpful. (RF 02)

While scientists and agricultural experts focused on demonstrating climate change impacts on crops and yields in decadal terms, most small grain farmers did not see the information initiating action as this information is incompatible with their short-term decision-making context. As one farmer noted, farmers look for current information about the weather and input costs, pests, and market prices to make it to the next season. Deciduous fruit farmers, on the other hand, found value in the long-term climate projections due to the nature of their crop, which is long-term in nature, contradicting the general sentiments by scholars such as Bradshaw et al. (2004) who contend that short-term climate information needs override long-term information needs. Interviews with rooibos farmers, on the other hand, revealed the need for information that is on a time scale of 5- 8 years. With these differences, it becomes essential to consider decision-support tools which provide different types of climate information for farmers, i.e., both long-term and seasonal climate information, to guide tactical and strategic decision-making (Prokopy et al., 2015).

Farmers also highlighted that the salience of the briefs and case study was significant from a theoretical point of view but was lacking from a practical point of view:

I find the content useful. It raised awareness and its alarming awareness, which they have raised in those reports. However, for a practical farmer, the next question is so what? I will have more droughts, goodness me, and so what., more floods, goodness me, and useful information, but so what. You created awareness, but you need to provide useful solutions you see. (RF01)

In line with the view of the rooibos farmer (RF01) the contestation around salience came down to the practicality of the information. It would appear from the verbatim that the farmer viewed the briefs as being detailed and good for awareness. However, farming goes beyond awareness and hence the agitation for practical information around solutions and direction for the farmers. Granted, awareness is key, but there is need for practical and consumable solutions, and should that be found within the briefs, the salience would not be in question.

Moreover, farmers noted the significance of detail in the case studies. As one farmer representative from deciduous fruit noted,

For case studies, what's more important are the nitty-gritties about what someone did, why, how they did it, and how it worked. I need proper and meaningful information. Just putting up a pretty picture with someone saying that "I should put up nets," will not work for me. To learn through what people have done means addressing those nitty-gritty questions like did they put up solid nets? Did they put up nets that you open? Did they change the rootstock? What rootstocks did they put? did they put it up on existing hot chip? did it work, or did the trees become vigorous afterward? So that kind of information. Just saying nets make plants cooler does not mean anything. (DF04)

From this excerpt, farmers argued against the theoretical and generalized advice that accompanied the analysis in the briefs and case study. According to Ingram et al. (2016), farmers seek detailed information on executing certain actions and the consequences (especially immediate ones) they will have. This was echoed by other farmers who argued that the most useful decision support tools provide concrete guidelines on farming practices and proper documentation that a certain change or practice will either increase yields or result in other benefits like savings

However, most farmers appreciated the effort by SmartAgri in putting together the case studies as they argued that it helps document good practice.

Farmers are very bad at recording things. Recording these things creates practice, and scientists putting all that experience together is critical and worth the weight of gold in showing us things going right or wrong (DF03).

Nevertheless, the need for more examples of what other farmers are doing was reemphasised

The whole narrative about climate change means nothing to me. We all know there is climate change, but giving me practical hands-on examples of what people have done, and that's worked for them, is fantastic (DF04).

The study also sought to find out the salience of the information channels that had been used in disseminating the briefs and the case study. In this regard, most farmers noted not receiving any information outputs or climate change adaptation information through the channels used by SmartAgri ie GreenAgri, print, AgriProbe newsletter, and radio programs. Most farmers noted that they spend most of their time in the field and hardly find time to read newsletters or go on websites to look for information. Moreover, they noted that they are often fraught with internet and connectivity challenges, making it a challenge to access anything online. Newsletters were also noted as an ineffective means to send information to farmers due to advertising clutter, with everyone trying to sell something to farmers.

However, farmers noted that although they cannot remember listening to climate change programs on RSG Radio, they use radio more than any other communication channels used by SmartAgri.

However, it was interesting to note that farmers argued that even if they had received the briefs and case study, they would not have read the documents. Farmers felt that the format and packaging of the briefs and the case study was not compatible with their busy schedules. One of the farmers even noted that

If it was not for this interview, I was not going to read those documents. "What I am saying is if you send that case study to 1000 farmers, I promise you that only one or two farmers will read that because it is text heavy and too huge to take to the field. It means that you must be in the office to go through it. I don't think it is a practical thing to do" (SG03)

From the excerpts above, it is evident that there is a disconnect between farmers and scientists and/ or agricultural experts insofar as communication is concerned. Whilst farmers were not arguing that the government is not communicating with them, they indicated that the communication platforms that were used were simply not what they use due their different contexts. This is in line with (Moser, 2010) who argues that context affects the channel of communication. The remoteness of most farmers and their busy schedules suggest the need to consider suitable ways of communication. Farmers provided their preferred channels of communication, and these are captured in a separate section.

4.4.3 Legitimacy

The study found that 70% of the farmers knew nothing about the SmartAgri plan and the engagement processes that were done in the production of the information outputs. A few that knew the plan argued that they did not engage with such processes due to a lack of knowledge of the engagements and time pressures. Thus, there existed mixed sentiments regarding Legitimacy insofar as farmers' participation was involved. Some farmers suggested poor marketing on the part of the plan. Most farmers argued that they are in different farming groups and are affiliated with various agribusinesses and commodity organisations, which could have been used to disseminate information on SmartAgri, as is noted in the comments below.

How were these meetings organized? We are involved in various committees, but no organisation ever came to talk to us about climate change..... I am talking about our local farming communities where all the farmers producing small grains in our little area meet monthly to discuss relevant issues affecting us as farmers. On a bigger scale, we are involved with Overberg Agri, our cooperate supplier for most of our agricultural inputs. Their footprint is wide. They stretch from the Swartland, on the West Coast, to the Rûens west side. On that level, we are involved with them and sometimes attend workshops, and we discuss different issues and give our input (SG 02)

I work mainly with Hortgro, a horticultural society in the Western Cape. I know all the stuff I saw in your brief, not through government or SmartAgri but through Hortgro.... If there are any meetings, they should go through Hortgro. It is the main body that disseminates information. It is the hub and a contact point for all the farmers in the industry. (DFF 02).

Generally, farmers felt that there needed to be more engagement of farmers in the information outputs produced. Others perceived the possibility of elite capture as they felt engagements were done with a few selected farmers without deliberate representation of farmers across commodities and geographic locations. These sentiments reduced perceptions of the plan's legitimacy as the information provided was perceived to have benefitted a few farmers.

Legitimate processes for climate change adaptation should ensure that all relevant stakeholders are involved and the process must be transparent, and fair (West et al., 2018). Farmers suggested that meetings with farmers should be organised through their respective commodity organisations or a team from SmartAgri must come on the ground to meet farmers through their local farming associations. One of the farmers also shared interesting insights on how farmer attendance at meetings could be enhanced. He suggested the need for the plan implementers to provide some form of incentive for farmers to attend. For instance, they were providing free lunches. He also noted that meeting organisers should also try to organise these meetings during days when farmers are not busy or when the weather is not allowing farmers to be in the field. This view is important as it speaks to inclusiveness. Although stakeholders participated in the Smart Agri plan, this view demonstrates that participation alone does not imply legitimacy. The quality of engagement, as well as who's opinions are solicited and considered, are crucial. (Neef and Neubert, 2011).

Some farmers also expressed the view that they felt an antagonistic relationship existed between themselves and the government at national level when it came to climate change issues. They argued that government does not engage them fully on climate change adaptation issues, but strikingly farmers are blamed when certain climate change adaptation initiatives fail. This is clear in the comment below.

There is a general conception and attitude that farmers are bad people. The problem is that we have a government that generally does not speak well about farmers, so anything that comes from the government, farmers are hostile towards them. They also have a very heavy-handed top-down approach and with that, people are reluctant. Huge amounts of land taxes we pay on these farms, and what the hell do we get out of it? Nothing. Something needs to be done at some stage.
(DF 03)

The perception of government animosity towards farmers was seen as an important factor affecting Legitimacy. Moreover, from the excerpt above, there was a perception of a top to bottom approach in the designing of climate change adaptation programs by government where farmers felt climate change adaptation programs are being pushed on farmers with little involvement of farmers in determining priority activities. According to the farmer (DF 03), the limited involvement of farmers in defining the plan's priority actions and heavy-handed

approaches limit the establishment of long-term connections necessary to enhance the legitimacy and credibility of processes for generating useful information that farmers can use.

Farmers also highlighted that they felt that the burden of climate change is being left to them to deal with, with no support provided to farmers. With this, some farmers questioned the legitimacy of climate change programs, as shown in the comments below.

We get bombarded with all types of information; not all is well intended. Most of the information is for their benefit, to sell something or promote a product. My job is to allocate resources; that is what I must do. I have got employees, and I have got a limited amount of capital I have to deploy and correctly allocate my resources so that everyone can benefit and so that my farm can be sustainable and make it to the next year (SG04)

Everything gets pushed to farmers. All we see is that the farmer should do this farmer should do without factoring in the burden that farmers already have. The problem with pushing the buck on to farmers is that there are no subsidies, making it difficult for farmers. So as much as that information makes sense, who will pay for the trials to test that information? It comes back to farmers, and we have no room for that (DF 04)

The findings above speak to commitment and transparency, and according to Swart et al. (2017), to avoid perceptions of bias by users of knowledge systems, there should be a total commitment from responsible institutions or project implementers through established support structures and financial support to strengthen user participation and enhance perceptions of the legitimacy of the interventions.

There was also a perception among farmers that ignoring water rights and governance issues by SmartAgri was based on something political rather than a legit process to help farmers. Farmers questioned the legitimacy of the plan, considering that little attention is being paid to how farmers are dealing with water challenges and how this is directly jeopardizing their livelihoods. Farmers, mainly deciduous fruit farmers, highlighted the need for the plan to take a wide livelihoods approach informed by farmers' feedback. They argued that the focus should not only be on climate change but also on other livelihood challenges they are facing. They

argued that adopting such an approach would give more credence to the work of the plan and clear perceptions that an agenda not aligned with people's concerns and interests is being pushed.

4.5 Farmers' Information Needs

Based on farmers' perceptions of the information outputs, the study further inquired into farmers' information needs. To this end, the researcher, through the interviews with the farmers, not only aimed to determine the kind of information that decision-makers deem useful but also to assess the preferred information formats and channels. The findings that emerged from the interviews are presented and discussed in the sub-sections below.

4.5.1 Short-Term Climate Information

In as much as deciduous fruit farmers welcomed the long-term climate projections, small grain farmers and rooibos farmers also noted the importance of short-term climate information as these are more relevant to their short-term decision contexts. They argued that their farming activities are seasonal and can be affected by unexpected weather changes. The interviews thus revealed that farmers were also interested in seasonal forecasts to plan for planting time and to know the temperatures and the rainfall patterns to expect.

If you can get short-term information, it is huge because we have started growing shorter grain varieties over the years. After all, the longer a crop is going to stay not harvested, the longer the potential you have for funguses and things like that. So that is why we are now into faster growing varieties. So, for farmers in small grain, the long-term stuff is irrelevant. The only person who might be interested in the long-term is one sitting with much surplus cash and does not know what to do with it (SG04)

I am in a farmers' group of about 12-15 farmers in our area here, and every morning, we share information about the rain. So, someone shares his information, and I share mine, and at the end of the day, we get an idea of the spread of the rain.

So, we are all interested in meteorology because seasonal differences are very pronounced in our area. If the meteorological information could be broken down by seasons and made it accessible, it could be helpful" (SGF01)

Rooibos is a seasonal commodity grown in the winter and harvested and processed in the summer. We can only harvest the rooibos if the temperatures are suitable to process. We need to know what the weather will be like four days before so that it dries well. We rely on weather conditions, so we need information on temperature, rain, and wind." (RF03).

From the interview text quoted above, it is evident that all the farmers across the various crops were interested in seasonal weather and climatic forecasts.

However, while most farmers demonstrated interest in short-term climate information and seasonal forecasts, their specific climate information needs to be varied across the commodity groups. Small grain and rooibos farmers highlighted the need-to-know information on temperature, rainfall patterns, i.e., when the rains start and stop and the precise periods in which rainfall will either increase or decrease. They also highlighted the need-to-know expected winds and temperatures that wind brings. The need for this information is backed by the comments below from the different small grain farmers.

In 2019 rain stopped in September, and we had a severe heat wave in spring when our plants were flowering. We had a "mis-oes" (total disaster) - So rainfall patterns are crucial, and if there is a prediction about heatwaves that particular year, it will also be important to know (SGF04)

One needs high temperature, low wind, and zero rainfall to process tea. In the planting season, you need rainfall, but not too much rainfall. The rainfall should be about 200-250mm. Wind predictions are also important because if the wind is too strong, it kills the plant, and if it is little, the tea will not dry properly. (RF 03)

On the other hand, the farmers of deciduous fruits noted that they are more interested in changes in chilling units. According to deciduous fruit farmers, knowing what is expected of chilling units can guide what varieties one can plant "you are not going to plant a high chilling apple if

you knew that there is a likelihood that 15 years down the line there is not going to be sufficient chill units" (DFF01). In this regard, interviews showed that climate information that is both short and long-term is of interest to the farmers given their different decision-making contexts. Moreover, the specific climate information and indicators they need vary according to their commodities.

4.5.2 Experiential Knowledge

The interviewees also highlighted the need for practical information, as illustrated below:

Farmers are very practical people because they make plans almost on a daily basis.

While some recommendations in the documents are good, they will remain on paper because of a lack of evidence. (SG04)

In this regard, while the farmers appreciate basic theory and scientific information, their argument is that science on its own is only partially valuable for them as they require practical information based on experience.

4.5.3 Pest Control and Weed Management

The farmers also revealed that they were interested in information regarding pest control and weed management.

How to control pests and weeds is the information we often look for. We get many weeds and pests here because of sporadic rains. That information would be helpful. (RF03)

This is driven by the fact that pests and weeds affect farming activities and the quality of the crop yield significantly. Pests also have a significant bearing on post-harvest management; hence, the need for such information was quite high amongst the farmers, particularly those producing Rooibos.

4.5.4 Water Rights and Governance and Alien Vegetation Management

The interest in information on how to address issues related to alien vegetation clearing, especially in the Ceres region, where farmers felt that alien vegetation will significantly impact fire and floods in the future because of limited fynbos to absorb water, was also noted. This, and concerns over limited information and movement on water rights and governance, continued to be emphasized by farmers, especially deciduous fruit farmers, who argued that ignoring these local development challenges will make it challenging for farmers to see how climate change adaptation information can enhance their resilience to climate change.

4.5.5 Preferred information Channels and Format

4.5.5.1 Printed handbooks

Farmers noted that they prefer future briefs and case studies to be packaged as pocket handbooks that they can take to the field. They also suggested that the handbooks should not be made heavy, preferring just guidelines and critical steps to be shown in the booklet. This is illustrated in the excerpt below.

A basic hand booklet with 50% guidelines on steps to do is more effective than having all those text-heavy documents in soft copy in pdf. For example, feed companies give us little booklets with basic guidelines on how to carry out specific procedures in the field, and it is quite handy and that booklet one can easily keep it in the vehicle and refer to it when the need arises. One can then do any in-depth research if they want more information (DFF 01)

Other farmers, however, preferred one-page documents with links to follow through for more information, as shown in the comment below.

Those two documents could have been summarized in one page then one could go in-depth through links if they wanted to. However, it would help if SmartAgri would capture readers in that one document made available. If I see a big 32 page with

a pretty picture, I will simply toss it away because I have many things to do. (DFF 04)

The preference for handbooks or one-pager documents is consistent with findings by Ingram et al. (2016) that hard copy notes are more effective since they are tangible, known to farmers, and can be taken to the field and be discussed in the field with an adviser.

4.5.5.2 Farmers Communities and Commodity Organisations

The interviews revealed that farmers have their farmers' unions in different communities where they meet and discuss issues. Farmers argued that SmartAgri should use these platforms to communicate directly with farmers. According to farmers, coming on the ground and meeting farmers in their own space helps legitimise any activities the plan is doing with them. However, some farmers felt that the program officials should come with someone that farmers know and trust, for instance, commodity organisations like Hortgro, Agri Western Cape, or Overberg Agri. Farmers argued that they work more closely with these bodies. This was confirmed in the comments below.

If the information came through Hortgro, it is far more credible because they have a sort of filtering mechanism where before information comes to farmers, it is filtered by someone knowledgeable about both farmers and science. Moreover, these organizations only send information that is useful to us. (DFF 04)

The best way is to use an industry body like Agri Western Cape, who could email us all. Those could be your contact points for farmers. They are also in the position to advise the plan on valuable content for farmers.

This brings out an important aspect on source credibility, where it was clear that farmers depend on and trust these groups to authenticate science for them. This, according to Ingram (2008), is typical of farmers especially when the topic is complicated. Farmers need specific guidance rather than what they view as "vague" information from scientific sources (Ingram, 2016).

4.5.5.3 Radio Programs

Since many farmers live in areas where the internet and mobile network is a challenge, radio was suggested as one of the best channels for disseminating climate change adaptation information to farmers. Most farmers interviewed noted that they listen to the RSG radio channels, as noted below.

As farmers, we spend much of our days operating the machines and usually listen to Africaans stations like RSG. Older generation farmers also listen to that. As a young farmer, I am not too keen on it. It is too old school for me. I would rather watch a good farming program on TV. (DFF01)

However, younger farmers indicated that they preferred TV programs to radio programs. Farmers noted that information from radio should be content that is salient to farmers. Content that speaks to their different commodities. Other farmers, however, argued that radio should only be used for light content like adverts and announcing events like farmer days, not heavy content like interviews.

4.5.5.4 Farmer Days

Famer days was also noted as a preferred channel for disseminating information. According to farmers, these platforms provide an opportunity to get salient information. For instance, according to one farmer, "There are often posters with climate and weather trends, and you can see for yourself and discuss with others" (SG02). Other farmers also noted that farmer days are an opportunity to meet with experts and have one-on-one sessions to ask them about your specific needs. However, according to one farmer, farmer days should have different experiments running at these events focusing on practical solutions for farmers. Looking at potential solutions for crop production is one example. Farmers being practical people who like to see evidence, argued that this would be a good platform for that. Farmers also noted that print materials are welcome at these events, but the focus should be on practical solutions for farmers.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In relation to communicating climate change adaptation information, this study sought to examine the usefulness of the CSL framework (Cash et al., 2003) in bridging the potential gap between information production and its use in decision-making by farmers in the Western Cape province of South Africa. The study's objectives were as follows: First, to Identify CSL-related factors that deter the utilisation of climate change adaptation information in decision-making at the science and farmer interface. Second, to examine information producers' perceptions of farmers' information needs and to what extent they perceive the selected case study and regional commodity briefs to be CSL for farmers' uptake. Third, to examine Western Cape commercial farmers' perceptions of the plan's selected case study and regional commodity briefs in terms of CSL. Fourth, to identify farmers' information needs based on farmers' perceptions of information that is CSL, and lastly, based on these objectives, to make recommendations for the development of more actionable climate change adaptation information and contribute to wider debates on bridging boundaries at the science-farmer interface.

The study results show that farmers face significant obstacles when trying to use information to make decisions about climate change. The findings showed that differences in access to different information channels, a lack of financial support for commercial farmers to put climate change adaptation interventions into action, a lack of experiential evidence, farmers' reluctance to adopt new practices, and the availability of information with little relevance to farmers' various contexts continue to undermine most farmers' use of climate change adaptation information in climate change decisions. These are the challenges that make bridging the gap between knowledge and action difficult.

The results also showed that the SmartAgri plan's objectives were heavily centred on creating scientific credibility. The information outputs were developed on the assumption that authoritative scientific analysis of climate change and the Western Cape's agricultural sector would provide credible information for climate action. With regards to Salience, the results showed that while there were efforts by scientists and agricultural experts under the plan to be

context specific by providing climate risks by agroclimatic zone and by commodity, to a greater extent, the information outputs were not set to respond to farmers' specific information needs. The main objective of the information outputs was to raise awareness on what science was saying about climate change and the Western Cape's agriculture. Regarding Legitimacy, the findings revealed that consultations were held with agricultural stakeholders, including government, value chain players in the private sector, and critical sectors such as water and biodiversity, with the outcomes feeding into the scoping and development of the information outputs. Thus, there were clear efforts to legitimise the work of SmartAgri. However, interviews with farmers, scientists, and agricultural experts reveal issues related to limited participation by farmers in these engagements, raising questions about the possibility of elite capture. However, according to scientists and agricultural experts, most of the stakeholders present at these engagements are accustomed to farmers' practices and contexts. Thus, this was enough to justify the process as thorough and fair in terms of the range of represented perspectives.

Consultation with farmers showed that Credibility is an important determinant of use of information. For a long time, scientific validity has been the currency for scientists (Cash et al., 2003), but this study showed the significance that farmers also place on this attribute. However, the results showed that perceptions of credibility are multidimensional, with farmers using a different criterion to determine what is valid and plausible. This was expressed in terms of the technical evidence's perceived scientific inadequacy and uncertainty in key climate variables such as rainfall. They felt both posed challenges to Credibility and undermined any potentially useful advice to farmers. When providing information and advice on climate change adaptation, most farmers emphasized the importance of evidence. However, there was disagreement about what constitutes evidence. While scientists and agricultural experts look at the authority of science, farmers stated that they prefer relying on both science and their own and other farmers' experiences for proof. Thus, the importance of empirically observing and validating climate change adaptation knowledge in practice with farmers was noted as critical in enhancing perceptions of credibility and use of climate change adaptation information.

Findings on Salience show that, although the plan did not set out to address farmers' specific information needs fully, Salience remains a critical attribute in determining the use of information in climate change decision-making. Fundamental differences in climate change adaptation information needs in terms of geographic and temporal scales, channels of delivery,

and information focus were revealed. The challenge of framing the knowledge outputs around climate change, a topic which is essentially not a motivating factor for farmers, was also noted. Farmers highlighted the failure of the briefs and case study to demonstrate economically viable ideas and to provide information that aligns with their priorities. This was the case with information on water governance and practical guidelines on how to implement adaptation practices. This demonstrated how farmers and scientists use different criteria to determine what information is salient.

Moreover, the findings revealed that the gap between research and practice is more complex than the polarized word suggests, with farmers themselves in their different commodity groups, each with their unique understanding of the kind and degree of salience necessary when providing information. This was shown in the instance of climate projections and climate indicators where long and short-term climate information, as well as specific climate indicators, were required depending on commodity specialisation and local context. This demonstrates the complexity of knowledge systems in the science and practice field and has implications for information delivery.

Iterativity has also long been underscored as an important aspect at the science-practice interface (Carberry et al., 2002; Oliver et al., 2012). The research presented here demonstrated that participation is critical, but on its own does not guarantee Legitimacy, as the nature, quality of participation, and individuals whose opinions are consulted and considered were all critical factors in this regard. The limited involvement of farmers in the plan's scoping and development of the briefs and the case study affected Legitimacy perceptions.

Despite these gaps, farmers generally regarded scientific information on climate change adaptation as potentially useful information that can increase farmers' resilience to climate change. Increasing experiential knowledge and specific information on water rights, as well as pests and weed control; employing multiple communication channels (traditional and modern), combining long-term climate information with short-term seasonal forecasts; and working closely with farmers through engaging knowledge brokers like producer organisations to help in information processing and sharing information were noted by farmers to increase the Credibility, Salience, and Legitimacy of climate change adaptation information sharing efforts and its useability.

In summary, the results suggest a disconnect between the scientific goals of the SmartAgri plan and farmers' information requirements. This is in a huge measure because of the overemphasis on Credibility by the plan, where there was much investment in creating authoritative and valid information, and in the process, undervaluing Salience and Legitimacy, which are fundamental values for farmers - the end users of the generated information. The findings highlighted the importance of scientists paying attention to farmer assessment of CSL attributes, as the findings demonstrated that scientists and farmers have different criteria related to CSL, as discovered by other scholars (Hegger et al., 2012; White et al., 2010). Results also showed that the criteria differ across farmer groups themselves. This division between scientists and farmers, as well as farmers about CSL, illustrates the complexity of knowledge systems within which players in science and practice operate. It is, therefore, oversimplified to believe that farmers lack knowledge or understanding to utilise climate change adaptation information, as this study has shown that farmers' information demands are different and multifaceted due to their different contexts. This study has shown that the CSL framework is an important heuristic for developing decision-support tools that accommodate the needs of various information users. Nevertheless, although the CSL framework is essential in developing actionable knowledge systems, the interplay between CSL attributes has hitherto received little attention. This study makes a clear case for the need for carefully designed studies in future (with controls) to ascertain the impact of this interplay to develop a robust climate response strategy for the agricultural sector.

5.2 Recommendations

Based on these findings, the recommendations below are made to improve the Credibility, Salience, and Legitimacy of climate change adaptation information for farmers in South Africa's Western Cape province.

For scientists and agricultural experts

- Scientists and Agricultural experts should take time to understand farmers' decision-making contexts through increased interactions and engagements with farmers. These engagements should ensure wide representation of farmers across commodities and regions in the Western Cape. Increasing dialogue opportunities with farmers will foster

greater understanding between science and practice, specifically reconciling the divide between CSL.

- There is also a need to present climate change adaptation information in a manner that is understandable and accessible to users in a language that is not overtaxing farmers' mental energy, time, and skills. Factsheets can be useful in this regard.
- Moreover, engaging knowledge brokers can help in information processing and sharing. Commodity organizations like Overberg Agri and Hortgro can play a vital role as climate change adaptation intermediaries considering their understanding of and relationship with farmers.
- Contrary to producing content and engaging stakeholders later, there is need to involve farmers in the research, design of decision support tools, and implementation of the plan much earlier. This will help build trust and achieve a fit that links science with users' values and goals. Farmers' knowledge needs and priorities should also be at the center of these efforts.
- Moreso, more case studies need to focus on specific climate change actions relevant to specific commodities and regions to improve perceptions of Salience.
- Breaking down climate information at different levels, for instance, real-time information, weather forecasts, seasonal forecasts, and long-term climate change projections, is also crucial for farmers' tactical and strategic decision-making.
- Given the disparities in access to different channels across the regions, SmartAgri should use a variety of distribution channels and cater to the varying information demands, preferences, and capacities of farmers. Considering that not all farmers currently have access to the internet, complementary delivery systems that expand on already established local pathways (such as farmers' community meetings, government extension services, and local producer companies) will intensify access to climate change adaptation information across the regions.
- It is also essential to recognise the political nature of South Africa's agricultural sector when recommending and offering advice about possible climate change adaptation measures. Understanding the financial obstacles that farmers may face in implementing knowledge on climate change adaptation is also crucial.

Farmers

- Farmers need to be responsive to calls for engagement and actively participate in meetings organised by scientists and agricultural experts. These shared platforms give equal access to stakeholders and are an opportunity to engender CSL.
- There is also a need for farmers to be disquiet about the limiting financial challenge and lobby the government for climate finance. Commodity organisations as brokers can play a critical role in that regard.

APPENDICES

Appendix 1: Letter of Invitation to SmartAgri



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To whom it may concern

R.E Invitation to Participate in a Research Study Project Title: *Building Western Cape farmers' resilience and adaptation to climate change through linking information to action: The usefulness of Credibility, Salience and Legitimacy*

Bridget Siziba (the researcher) is an MPhil Student with the University of Cape Town under the ACDI, Masters in Climate Change and Sustainable Development Program. She is carrying out a study with commercial farmers and **SmartAgri** project experts to examine the usefulness of the Credibility, Salience and Legitimacy (CSL) approach in bridging the potential disconnect between knowledge production and its use for adaptation by commercial farmers in the Western Cape.

Credibility has to do with the trustworthiness, reliability and dependability of the information upon which to base decisions. **Salience** on the other hand, considers the perceived relevance of the information to the needs of decision-makers. Lastly, **Legitimacy** considers perceptions that the production of information has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of views and interest.

To carry out this study, the researcher proposes to use Western Cape's SmartAgri project as a case study and the focus will be on two communication products that is (**case studies and regional and commodity briefs**) that were produced by scientists and agricultural experts of SmartAgri project. The aim is to understand how these information products were/are considered useful or CSL by both the producers and users of the information. Your experience would be a valuable source of information, and the hope is that by participating you may gain useful knowledge.

Procedures: During the study, you will be asked for your consent to participate in the study. After registering your consent, you will be invited to an online Zoom session where you and the researcher will discuss your perceptions of the SmartAgri communication products as well as the communication barriers and the kind of information that would garner commercial farmers' action towards Climate Change.

Recording: The researcher may record the data collection sessions as part of the study. The recorded sessions which will be audio will be used only for data analysis. If you object to this, you are free to let the researcher know.

Risks: There are no potentially harmful risks related to your participation in this study. The researcher has applied UCT's strict research ethical protocols to the design of the project and has received ethical clearance from the Faculty of Science Research Ethics Committee.

Feedback: You will receive feedback about the results of this research where a copy of this thesis will be shared with each one of you by email after completion of the study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

"Our Mission is to be an outstanding teaching and research university, educating for life and addressing the challenges facing our society."

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

Please do not hesitate to contact me if you have any further questions: 021 650 2838 or marieke.norton@uct.ac.za.

Kind regards,

A handwritten signature in black ink, appearing to read 'Marika' or 'Marika Norton', written in a cursive style.

Marieke Norton
ACDI Course Convenor

Appendix 2: Informed Consent form for Scientists and agricultural experts

DEPARTMENT OF ENVIRONMENTAL AND GEOGRAPHY SCIENCES

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Informed Voluntary Consent to Participate in Research Study

Project Title: Building Western Cape farmers' resilience and adaptation to climate change through linking information to action: The usefulness of Credibility, Salience and Legitimacy framework

Invitation to participate, and benefits: You are invited to participate in a research study conducted with commercial farmers and SmartAgri project experts. The study aim is to examine the usefulness of the Credibility, Salience and Legitimacy approach in bridging the potential disconnect between knowledge production and its use for adaptation by commercial farmers in the Western Cape. **Credibility** has to do with the trustworthiness, reliability and dependability of message claims upon which to base decisions. **Salience** on the other hand considers the perceived relevance of the information to the needs of decision-makers. Lastly, **Legitimacy** has to do with perceptions that the production of information has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of views and interest. To carry out this study, Western Cape's SmartAgri project will be used as a case study and the focus will be on two communication products (**case studies and regional and commodity briefs**) that were produced by scientists and agricultural experts of SmartAgri project. The aim is to understand how these information products were considered CSL by both the producers and users of the information. Your participation in this research will be of great importance in understanding the potential disconnect between information production and its use in decision making. The study will provide valuable feedback which will allow climate adaptation information to be developed, customized and communicated in ways that are consistent with the users' needs.

Procedures: Firstly, you will be asked for your consent to participate in the study. After you register your consent, you will be invited to an online discussion on Zoom to discuss the goal of the project and development of climate adaptation information outputs for farmers' resilience to climate change. The discussion will also try to understand your perceptions of the regional commodity briefs and case studies.

Recording: The researcher may record audio as part of the study. This will solely be for data analysis purposes.

Risks: There are no potentially harmful risks related to your participation in this study.

Feedback: You will receive feedback about the results of this research where a copy of this thesis will be shared with each one of you by email after completion of the study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may withdraw from the study at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

What signing this form means: By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I agree to participate in this research (tick one box) ☐ Yes ☐ No _____ (Initials)
[The following statements are suggested items only and may be replaced or deleted as appropriate for your study.]

I agree to be photographed ☐ Yes ☐ No _____ (Initials)

I agree to be audio-recorded ☐ Yes ☐ No _____ (Initials)

I agree to be video-recorded ☐ Yes ☐ No _____ (Initials)

I agree to the use of properly anonymized photographs/audio recordings/videos [researcher to delete as applicable] in the following way –[provide details] ☐ Yes ☐ No _____ (Initials)

Name of Participant

Signature of Participant

Date

Bridget Siziba

Name of Researcher

BNSiziba

Signature of Researcher

Date

Bridget. N. Siziba

Appendix 3: Informed Consent form for Farmers

DEPARTMENT OF ENVIRONMENTAL AND GEOGRAPHY SCIENCES

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Informed Voluntary Consent to Participate in Research Study

Project Title: Building Western Cape farmers' resilience and adaptation to climate change through linking information to action: The usefulness of Credibility, Salience and Legitimacy

Invitation to participate, and benefits: You are invited to participate in a research study conducted with commercial farmers and SmartAgri project experts. The study aim is to examine the usefulness of the Credibility, Salience and Legitimacy approach in bridging the potential disconnect between knowledge production and its use for adaptation by commercial farmers in the Western Cape. **Credibility** has to do with the trustworthiness, reliability, and dependability of message claims upon which to base decisions. **Salience** on the other hand considers the perceived relevance of the information to the needs of decision-makers. Lastly, **Legitimacy** has to do with perceptions that the production of information has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of views and interest. To carry out this study, Western Cape's SmartAgri project will be used as a case study and the focus will be on two communication products (**case studies and regional and commodity briefs**) that were produced by scientists and agricultural experts of SmartAgri project. The aim is to understand how these information products were considered CSL by both the producers and users of the information. Your participation in this research will be of great importance in understanding the disconnect between information production and its use in decision making. Your valuable feedback will allow adaptation information to be developed, customized, and communicated in ways that are consistent with the users' needs.

Procedures: During this study, you will be asked for your consent to participate in the study. After you register your consent, you will be invited to an online focus group discussion on Zoom to discuss perceived barriers to the use of adaptation information in decision making, your perceptions on the credibility, salience, and legitimacy of SmartAgri regional commodity briefs and case studies and what should be done by SmartAgri to garner effective use of adaptation information in farm decision making by commercial farmers.

Recording: The researcher may record audio as part of the study. This will solely be for data analysis purposes. If you object to this, you are free to notify the researcher.

Risks: There are no potentially harmful risks related to your participation in this study.

Feedback: You will receive feedback about the results of this research where a copy of this thesis will be shared with each one of you by email after completion of the study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may withdraw from the study at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

What signing this form means: By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I agree to participate in this research (tick one box) ☐ Yes ☐ No _____ (Initials)
 [The following statements are suggested items only and may be replaced or deleted as appropriate for your study.]
 I agree to be photographed ☐ Yes ☐ No _____ (Initials)
 I agree to be audio-recorded ☐ Yes ☐ No _____ (Initials)
 I agree to be video recorded ☐ Yes ☐ No _____ (Initials)
 I agree to the use of properly anonymized photographs/audio recordings/videos [researcher to delete as applicable] in the following way [provide details] ☐ Yes ☐ No _____ (Initials)

_____	_____	_____
Name of Participant	Signature of Participant	Date
_____	_____	_____
Name of Researcher	Signature of Researcher	Date
Bridget. N. Siziba		

Appendix 4: Scientist and Agricultural expert FGD Guide

SMARTAGRI KEY INFORMANTS (SCIENTISTS AND/OR AGRICULTURE EXPERTS) –INTERVIEW GUIDE

Masters' Thesis: Building Western Cape farmers' resilience and adaptation to climate change through linking information to action: The usefulness of Credibility, Salience and Legitimacy

Introduction

My name is Bridget Siziba, a Master's student at the University of Cape Town. I am carrying out a study which aims to assess the usefulness of the Credibility, Salience and Legitimacy framework in linking climate adaptation information to action for farmers resilience and adaptation to climate change. I am carrying out this study as partial fulfilment of my Master's in Climate Change and Sustainable Development with the African Climate Development Initiative at the University of Cape Town. Your participation in this process is voluntary, you are free to not answer any question and to leave the discussion whenever you like. Information collected here is solely for academic purposes and will not be used in any way that harms the informant. The information will be used in the strictest way possible with your names remaining anonymous, and not presented in the final report. You are also free to ask questions and clarification at any point during the interview. The information generated from this discussion will help in informing /improving the development and communication of climate adaptation information for farmers.

Province : Western Cape	Organisation:	Number of participants	
Interview Method	Zoom		
Participants' Names		Role	
Dr. Ilse Trautmann		Chief Director: Research and Technology Development Services, Department of Agriculture, Western Cape	
Professor Stephanie Midgely		Researcher and SmartAgri Project Manager	
Dr Johann Strauss		Senior Scientist and Sustainable Cropping Systems Researcher	
Dr Mike Wallace		Specialist Scientist, Department of Agriculture, Western Cape	
Facilitator Name		Bridget Siziba	
Start time		End time	
Date			

Project Initiation

1. As the experts behind the conceptualisation of the Smart Agriculture for Climate Resilience/ SmartAgri plan, can you please share briefly what the project is about?
2. When you developed the regional commodity briefs and case studies, what was the goal and who were you targeting?
3. Can you say you have been successful in achieving that goal?

O2: Information producers' perceptions of the information outputs

CREDIBILITY (source credibility and content credibility)

4. How do you rate the reliability of the information in the briefs (ie the climate change projections, crop specific risks and proposed adaptation measures) ?

a. Fair ☐ b. Reliable ☐ c. Very Reliable ☐ d. Not reliable ☐

5. How can you rate the reliability of the information in the DRM case study (ie the anticipated disasters, DRM systems and their effectiveness in managing current and future risks) ?

a. Fair ☐ b. Reliable ☐ c. Very Reliable ☐ d. Not reliable ☐

6. Please explain your responses in question 4 and 5
7. What data sources were used to inform these specific information outputs? And how reliable are these sources?
8. How did you deal with the inherent uncertainties in climate projections and also future land use changes and context specific complexities when developing the outputs?

Process credibility

9. What other steps have you taken in the development of commodity briefs and the case study to ensure that you are providing farmers with reliable information for their uptake?
10. Which scientific disciplines were integrated in the production of the briefs and the DRM case study.
11. How were the different disciplines integrated in the process?
12. Among these disciplines are there some that are more credible than others?

13. Were there any efforts made to incorporate farmers' views and knowledge in the development of these outputs? Yes/No?
14. If yes, what engagement processes have you used to elicit farmers' views and knowledge in the development of these information outputs _____
15. Were there any challenges in that regard. _____
16. Apart from the scientists and Western Cape Gov, are there other participants (Organisations or individuals) that have played a role in disseminating and promoting awareness of these information outputs to farmers under the SmartAgri plan and what was their role? (Probe for extension workers, farmer groups , NGOs etc)
17. Between these two forms of evidence: **scientific knowledge and experiential knowledge** which of the two has been the main focus by the SmartAgri plan to ensure that credible information is being disseminated to farmers

and why? _____
18. Have you had a situation where information you provided in the briefs and case studies is contested by farmers based on their experience and perceptions?
19. If yes how have you addressed such challenges?

SALIENCE: RELEVANCE OF INFORMATION TO USERS

20. From your understanding of commercial farmers, what type of content do think commercial farmers need for their climate adaptation decision making?.
21. Do you think the briefs and case studies have adequately addressed those information needs you mentioned above.
22. What potential utility do the commodity briefs provide to commercial farmers?
(Probe for the following)
 - a) Do the briefs demonstrate economic benefits and costs associated with farmers adopting the cc adaptation measures?
 - b) Is the content in the briefs context specific enough to be used in the specific regions and commodity groups in Western Cape (e.g probe for availability of information by geographical area, by commodity and at different time scales e.g climate change projections, real-time information, weather forecasts, seasonal predictions)

c) In your opinion, how divisible is the action required (breakdown of a change in behaviour into the required steps) for farmers to start implementing DRM

23. What utility does the DRM case study provide to commercial farmers' climate adaptation information needs?

(Probe for the following)

- a) Do you think you have been able to provide enough evidence on how DRM can benefit farmers? (e.g. where it has worked and other farmers who have implemented it)
- b) Does the case study provide farmers with the economic benefits and costs associated with implementing

LEGITIMACY

24. During Smart Agri engagement meetings with farmers were there efforts made to incorporate farmers views and knowledge?

25. Was there co-production of these specific knowledge outputs with farmers

26. If yes, how was this process done

27. Do you think there is mistrust of the SmartAgri plan by farmers.

O1: CSL related factors that hinder the use of adaptation information in decision-making

28. What challenges have you experienced in disseminating the briefs and case study to farmers under the SmartAgri plan?

29. In your opinion, what could be the barriers in general to farmers' use of climate adaptation information in their decision making? *(Probe for information uncertainty, trust issues between SmartAgri and farmers, uncertainty embedded in climate adaptation information, the scale of assessment that climate adaptation focuses on which does not always match the scale required for a potential adaptation response, the level of skill needed to exploit the information)*

30. How have you attempted to address the barriers you mentioned above?

.....**THANK YOU FOR YOUR TIME**.....

Appendix 5: Commercial Farmers' Interview guide

COMMERCIAL FARMERS –INTERVIEW GUIDE

Masters' Thesis: Building Western Cape farmers' resilience and adaptation to climate change through linking information to action: The usefulness of Credibility, Salience and Legitimacy

Introduction

My name is Bridget Siziba, a Master's student at the University of Cape Town. I am carrying out a study which aims to assess the usefulness of the Credibility, Salience and Legitimacy framework in linking climate adaptation information to action for farmers resilience and adaptation to climate change. I am carrying out this study as partial fulfilment of my Master's in Climate Change and Sustainable Development with the African Climate Development Initiative at the University of Cape Town. Your participation in this process is voluntary, you are free to not answer any question and to leave the discussion whenever you like. Information collected here is solely for academic purposes and will not be used in any way that harms the informant. The information will be used in the strictest way possible with your names remaining anonymous, and not presented in the final report. You are also free to ask questions and clarification at any point during the interview. The information generated from this discussion will help in informing /improving the development and communication of climate adaptation information for farmers.

Province : Western Cape		Area:		Farmers' Code name e.g. RH1 (rooibos farmer 1)
Interview Method	Telephone			
Farmer category	<i>Commercial Farmer</i> Small grain ☐ Rooibos ☐ Deciduous ☐ fruits			
Facilitator Name	Bridget Siziba			
Start time	End time			
Date				

Project Initiation

1. Are you are aware of the Smart Agriculture for Climate Resilience/ SmartAgri plan?

Yes ☐ No ☐

2. Are you aware of the case studies and regional commodity briefs that were disseminated under the plan to support farmers with practical information on resilience and adaptation to climate change?

Yes ☐ No ☐

3. In your opinion What do you think is the intention of the project? (**This question is also important for assessing legitimacy perceptions**)

O2: Information producers' perceptions of the information outputs

CREDIBILITY (source credibility, process credibility and content credibility)

Source Credibility

4. How do you rate the reliability of the information in the briefs (ie the climate change projections, crop specific risks and proposed adaptation measures) ?

a. Fair ☐ b. Reliable ☐ c. Very Reliable ☐ d. Not reliable ☐

5. How do you rate the reliability of the information in the DRM case study (ie the anticipated disasters, DRM systems and their effectiveness in managing current and future risks) ?

a. Fair ☐ b. Reliable ☐ c. Very Reliable ☐ d. Not reliable ☐

5. Please explain your responses in question 4 and 5

6. Do you have any uncertainties with the information provided in the briefs? (Probe for uncertainties with climate projections and future land changes?)
7. Do you have any uncertainties with the information provided in the case study ? (Probe for uncertainties with regards to evidence provided in the case studies)
8. If yes, how do these uncertainties affect your use of both the brief and the case study?
9. Have you had a situation where you find information provided in the briefs and case studies contestable based on your experience and perceptions?

10. Between these two aspects of climate change adaptation information, **scientific knowledge versus experiential knowledge** which one do you trust the most for your climate adaptation planning and decision making and why?

Scientific validity ☐ Experiential knowledge ☐ Both ☐

and why? _____

11. Are there sources of information sources which you trust the most or consider as most credible for your farm decision making. If yes which are those?
12. Did you participate in the Smart Agri district meetings which shared and unpacked implications of Climate Change on Western Cape to Agricultural stakeholders.
13. If yes, was the process satisfactory in your view ? and why?
14. If no, what engagement processes would better elicit farmers' participation

SALIENCE RELEVANCE OF THE KNOWLEDGE TO FARMERS

15. What utility does the scientific background in the briefs ie climate change and impacts on your commodity and in Western Cape provide to you?
16. What utility does the DRM case study provide to your climate adaptation information needs? (**Probe for the following:** ie availability of enough evidence on how DRM can benefit farmers? , clear economic benefits and costs associated with implementations and divisibility of the adaptation action required (breakdown of a change in behaviour into clear steps)
17. How can the information in the brief and case study be made more context specific for your area and commodity
18. What kind of content do you think would be more important to include in the briefs and case studies for effective climate adaptation decision making?
19. Has this information been packaged in a way that meets your information needs.
20. If no, in what format do you prefer climate adaptation information coming to you e.g. (radio podcasts, video podcasts, Fact sheets, social media infographics, GIS Maps, real life examples, participatory learning etc)?
21. In your opinion how else could adaptation information be presented to you in a way that would most help you use it?

22. Did you access the briefs and case studies from any of the below channels

(GreenAgri website, printed copies through workshops, Links in Agriprobe newsletter)

23. How effective are these channels in reaching you with information

24. Have you ever received any other information on climate adaptation from SmartAgri via any of the following channels (radio, farmer days, newsletters, annual conferences and workshops)

25. Is there a better way that information can be made available and accessible to you?

LEGITIMACY

26. During farmers engagement meetings with SmartAgri, did you feel like your views and knowledge were valued?

27. If no what should be done to better elicit farmers' views and knowledge in the development of climate adaptation information outputs _____

28. Would you welcome the opportunity to co create knowledge with the SmartAgri

29. How best can this process be done in your opinion

30. In your opinion what is the intention of the SmartAgri plan or do you feel their intentions are genuine.

O1: CSL related factors that hinder the use of adaptation information in decision-making

31. In general and in your opinion, what could be some of the barriers in the way of farmers' use of SmartAgri's climate adaptation information in decision making? (*Probe for information uncertainty, trust issues between SmartAgri and farmers, uncertainty embedded in climate adaptation information, the scale of assessment that climate adaptation focuses on which does not always match the scale required for a potential adaptation response, the level of skill needed to exploit the information*)

32. How can the barriers you mentioned above be addressed in your opinion

.....**THANK YOU FOR YOUR TIME**.....

REFERENCES

1. Archer, E., Landman, W., Malherbe, J., Tadross, M. and Pretorius, S., 2019. South Africa's winter rainfall region drought: A region in transition?. *Climate Risk Management*.
2. Adamsone-Fiskovica, A. & Grivins, M. 2022. Knowledge production and communication in on-farm demonstrations: putting farmer participatory research and extension into practice. *The Journal of Agricultural Education and Extension*, 28(4)
3. Adger, W.N., Arnell, N.W., Tompkins, E.L., 2005. Successful adaptation to climate change across scales. *Glob. Environ. Chang.* 15, 77–86. <https://doi.org/10.1016/j.gloenvcha.2004.12.005>
4. Albertson, E.M., 2012. Linking Urban Agriculture Knowledge to Action for Sustainable Development: The Case of a South African Urban Farm Network (Doctoral dissertation, Stanford University).
5. Amars, L., Fridahl, M., Hagemann, M., Röser, F., Linnér, B O. 2017. "The transformational potential of Nationally Appropriate Mitigation Actions in Tanzania: assessing the concept's cultural legitimacy among stakeholders in the solar energy sector" *Local Environment* 22(1):86-105
6. Archer van Garderen, E.R.M., 2011. (Re) Considering cattle farming in Southern Africa under a changing climate. *Weather, Climate, and Society*, 3(4), pp.249-253.
7. Archer, E., Landman, W., Malherbe, J., Tadross, M. and Pretorius, S., 2019. South Africa's winter rainfall region drought: A region in transition? *Climate Risk Management*, 25, p.100188.
8. Asplund, T. 2018. Communicating Climate Science: A Matter of Credibility—Swedish Farmers' Perceptions of Climate-Change Information." *The International Journal of Climate Change: Impacts and Responses* 10 (1): 23-38. doi:10.18848/1835-7156/CGP/v10i01/23-38. DOI: <https://doi.org/10.18848/1835-7156/CGP/v10i01/23-38>
9. Baker, B. & Viglizzo, J.E., 1998. 'Rangelands and livestock,' in J.F. Feenstra, I. Burton, J.B. Smith & R.S. Tol (eds.). *Handbook of methods for climate change impact assessment and adaptation strategies*. IVM/UNEP Version 2.0.

10. Baleta, H. & Pegram, G. 2014. Climate change implications for the Southern African Development Community (SADC).
11. Barnard, G., 2014. Seeking a cure for portal proliferation syndrome. Climate and Development Knowledge Network. <<http://cdkn.org/2011/06/portalproliferation-syndrome/>>
12. Barriball, K. L. & While., A. 1994. Collecting data using a semi-structured interview: a discussion paper. *Journal of Advanced Nursing*, 19(2), 328–335. DOI:10.1111/j.1365- 2648. 1994.tb01088.x
13. Baxter, P., & Jack, S. 2008. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, 13(4), 544–556.
14. Baxter, P. & Jack, S. 2010. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *Qualitative Report*. 13.
15. Baylis, M., Githeko, A.K. 2006. The effects of climate change on infectious diseases of animals. Report for the Foresight Project on Detection of Infectious Diseases, Department of Trade and Industry, U.K. Government. 35.
16. Beier, P., Hansen, L.J., Helbrecht, L. and Behar, D. 2017. A how-to guide for coproduction of actionable science. *Conservation Letters*, 10(3), pp.288-296.
17. Beilfuss, R. 2012. A Risky Climate for Southern African Hydro: assessing hydrological risks and consequences for Zambezi River Basin Dams, D.O. - 10.13140/RG.2.2.30193.48486.
- 18.** Benford, R.D. and Snow, D.A. 2000. Framing processes and social movements: An overview and assessment. *Annual review of sociology*. 26(1), pp.611-639.
19. Benhin, J.K.A., 2006, Climate change and South African agriculture: Impacts and adaptation options, Centre for Environmental Economics and Policy in Africa (CEEPA), Discussion Paper no 21, University of Pretoria, Pretoria, South Africa.
20. Bisbal, Gustavo, A. 2018. Practical tips to establish an actionable science portfolio for climate adaptation. *Science and Public Policy*, (), –. doi:10.1093/scipol/scy070

21. Blamey, R., Jack, C., Steynor, A., Sutherland, K., & Taukoor, S. 2014. Climate science input into municipal climate adaptation plans. Western Cape Government: Climate System Analysis Group University of Cape Town.
22. Botai, C.M., Botai, J.O., De Wit, J.P., Ncongwane, K.P. and Adeola, A.M., 2017. Drought characteristics over the western cape province, South Africa. *Water*.
23. Bradshaw, B., Dolan, H., Smit, B., 2004. Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies. *Clim. Change* 67, 119e141.
24. Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, pp.77-101.
25. Briley, L., Brown, D., Kalafatis, S.E., 2015. Overcoming barriers during the coproduction of climate information for decision-making. *Clim. Risk Manag.* 9, 41–49. <https://doi.org/10.1016/j.crm.2015.04.004>
26. Brittain, S., Ibbett, H., Lange, E., Dorward, L., Hoyte, S., Marino, A., ... Lewis, J. (2020). Ethical considerations when conservation research involves people. *Conservation Biology*. doi:10.1111/cobi.13464
27. Browning, G., Halcli, A. and Webster, F. eds., 1999. *Understanding contemporary society: Theories of the present*. Sage.
28. Brügger, A., Dessai, S., Devine-Wright, P., Morton, T.A. and Pidgeon, N.F., 2015. Psychological responses to the proximity of climate change. *Nature climate change*, 5(12), pp.1031-1037. doi:10.1038/nclimate2760
29. Bruine de Bruin, W., & Bostrom, A. 2013. Assessing what to address in science communication. *Proceedings of the National Academy of Sciences of the United States of America*, 110(Supplement 3), 14062– 14068. doi:10.1073/pnas.1212729110
30. Buizer, J., Jacobs, K., Cash, D. 2010. Making short-term climate forecasts useful: Linking science and action. *Proc Natl Acad Sci USA* 113:4597–4602.

31. Cachia, M. and Millward, L., 2011. The telephone medium and semi-structured interviews: a complementary fit. *Qualitative Research in Organizations and Management: An International Journal*.
32. Carberry, P., Hochman, Z., Mccown, R., Dalgliesh, N., Foale, M., Poulton, P., Hargreaves, J., Hargreaves, D., Cawthray, S., Hillcoat, N., 2002. The FarmScape approach to decision support: farmers', advisers', researchers' monitoring, simulation, communication, and performance evaluation. *Agric. Syst.* 74, 141e177.
33. Carlton, J S., Perry-Hill, R., Huber, M., Prokopy, L S. 2015. "The climate change consensus extends beyond climate scientists" *Environmental Research Letters* 10(9):094025
34. Carr, E. R., & Onzere, S. N. 2018. Really effective (for 15% of the men): Lessons in understanding and addressing user needs in climate services from Mali. *Climate Risk Management*, 22, 82–95. <https://doi.org/10.1016/j.crm.2017.03.002>
35. Carr, E. R., Goble, R., Rosko, H. M., Vaughan, C., & Hansen, J. 2020. Identifying climate information services users and their needs in Sub-Saharan Africa: A review and learning agenda. *Climate and Development*, 12(1), 23–41. <https://doi.org/10.1080/17565529.2019.1596061>
36. Carter, S.M., Shih, P., Williams, J., Degeling, C. and Mooney-Somers, J., 2021. Conducting qualitative research online: Challenges and solutions. *The Patient-Patient-Centered Outcomes Research*, 14(6), pp.711-718.
37. Cartwright, A. 2002. When apples don't sleep: The impact of warmer climates on Braeburn apple production in the winter rainfall region of South Africa. MSc thesis, Environmental Change Institute, Oxford University, U.K.
38. Cash, D.W. and Moser, S.C. 2000. Linking global and local scales: designing dynamic assessment and management processes. *Global Environmental Change-Human and Policy Dimensions*, 10(2), 109–120.
39. Cash, D.W., Clark W.C., Alcock F, Dickson, N.M., Eckley N, et al. 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America*, 100(14), 8086–8091.
40. Cash, D.W., Borck J.C., Patt, A.G. 2006. Countering the loading-dock approach to linking science and decision-making: comparative analysis of El Nino/Southern Oscillation (ENSO) forecasting systems. *Sci. Technol. Hum. Values* 31:465–94 .

41. Cash, D.W., Belloy, P.G. 2020. Salience, Credibility and Legitimacy in a Rapidly Shifting World of Knowledge and Action. *Sustainability*, 12(18), 7376–. doi:10.3390/su12187376

42. Clark, W. C., Tomich, T. P., van Noordwijk, M.; Guston, D.; Catacutan, D.; Dickson, N. M.; McNie, E. 2011. Inaugural Article: Knowledge Systems for Sustainable Development Special Feature Sackler Colloquium: Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR). *Proceedings of the National Academy of Sciences*, (), 0900231108–. doi:10.1073/pnas.0900231108

43. Clark, W.C., Tomich, T.P., van Noordwijk, M., Guston, D., Catacutan, D., Dickson, N.M., & McNie, E. 2016. Boundary work for sustainable development: Natural resource management at the Consultative group on International agricultural research (CGIAR). *Proceedings of the National Academy of Sciences*, 113(17), 4615–4622. doi:10.1073/ pnas.0900231108

44. Conway, D., van Garderen, E.A., Deryng, D., Dorling, S., Krueger, T., Landman, W., Lankford, B., Lebek, K., Osborn, T., Ringler, C. and Thurlow, J., 2015. Climate and southern Africa’s water–energy–food nexus.

45. Crane, T.A., Roncoli, C., Paz, J., Breuer, N., Broad, K., Ingram, K.T. & Hoogenboom, G. 2010. Forecast skill and farmers’ skills: Seasonal climate forecasts and agricultural risk management in the southeastern United States. *Weather, Climate, and Society*. 2(1):44- 59.

46. Dai, A., 2011. Drought under global warming: a review. *Wiley Interdisciplinary Reviews: Climate Change*, 2(1), pp.45-65.

47. Davis-Reddy, C.L., Vincent, K. and Mambo, J., 2017. Socio-economic impacts of extreme weather events in Southern Africa. CSIR.

48. Department of Environmental Affairs (DEA).,2011. National Climate Change Response Plan White Paper. Department of Environmental Affairs: Pretoria, South Africa.

49. Department of Environmental Affairs and Development Planning., 2016. Western Cape Government.

50. Department of Water Affairs and Forestry (DWAF., 2002. Proposed first edition, National Water Resource Strategy, Pretoria.
51. Deakin, H., & Wakefield, K. 2013. Skype interviewing: Reflections of two Ph.D. researchers. *Qualitative Research*, 14(5), pp 603–616. Doi:10.1177/1468794113488126
52. Dessai, S., Hulme, M., Lempert, R., Pielke Jr, R., 2009. Climate prediction: a limit to adaptation, in: Adger, W.N., Lorenzoni, I., Karen, L.O. (Eds.), *Adapting to Climate Change: Thresholds, Values, Governance*. Cambridge University Press, pp. 64–78. <https://doi.org/http://dx.doi.org/10.1017/CBO9780511596667.006>
53. Dilling, L., Lemos, M.C. 2011. Creating usable science: opportunities and constraints for climate knowledge use and their implications for science policy. *Glob. Environ. Change* 21:680–89 17.
54. Dilling, L. and Failey, E., 2013. Managing carbon in a multiple use world: The implications of land-use decision context for carbon management. *Global environmental change*, 23(1), pp.291-300.
55. Dumbrell, N.P., Kragt, M.E., Gibson, F.L., 2016. What carbon farming activities are farmers likely to adopt? A bestworst scaling survey. *Land Use Policy* 54, 29e37
56. Du Plessis, J A and Schloms, B. 2017. An investigation into the evidence of seasonal rainfall pattern shifts in the Western Cape, South Africa. *J. S. Afr. Inst. Civ. Eng.*.vol.59. pp.47-55. <http://dx.doi.org/10.17159/2309-8775/2017/v59n4a5>.
57. Dupuis, J., Biesbroek, R., 2013. Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Glob. Environ. Chang.* 23, 1476–1487. <https://doi.org/10.1016/j.gloenvcha.2013.07.022>
58. Ernst, K.M.; Swartling, A. G., André, K.; Preston, B. L.; Klein, R.J.T. 2019. Identifying climate service production constraints to adaptation decision-making in Sweden. *Environmental Science & Policy*, 93(), 83–91. doi:10.1016/j.envsci.2018.11.023
59. Eshuis, J., Stuiver, M., 2005. Learning in context through conflict and alignment: farmers and scientists in search of sustainable agriculture. *Agric. Hum. Values* 22, 137e148.

60. Farrell, A.E, Jager,J., eds. 2006. " Assessments of Regional and Global Environmental Risks: Designing Processes for the Effective Use of Science in Decision-making. Washington, DC: Resour. Future
61. Farrel, D et al., 2020. Evaluation of the Diagnostic. Design and Implementation of the Western Cape Agricultural Sector Climate Change Framework and Implementation Plan (SmartAgri).
62. Fenig, S., Levav, I., Kohn, R. and Yelin, N., 1993. Telephone vs face-to-face interviewing in a community psychiatric survey. *American journal of public health*, 83(6), pp.896-898.
63. Findlater, K.M. 2013. Conservation Agriculture: South Africa's New Green Revolution?
64. Findlater, K.M., 2017. Explaining climate-sensitive decision-making: On the relationship between cognitive logic and climate-adaptive behaviour (Doctoral dissertation). 10.14288/1.0345608.
65. Frank, E., Eakin, H. , Lopez-Carr,D. 2011 Social identity, perception, and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Global Environ Change* 21:66–76
66. Franks J. 2010. Boundary organizations for sustainable land management: the example of Dutch Environmental Co-Operatives. *Ecol. Econ.* 70:283–95
67. Fleming, A., & Vanclay, F. 2011. Farmer Responses to Climate Change and Sustainable Agriculture. *Sustainable Agriculture Volume 2*, 283–293. doi:10.1007/978-94-007-0394-0_15
68. Furman, C., Roncoli, C., Crane, T. and Hoogenboom, G., 2011. Beyond the “fit”: Introducing climate forecasts among organic farmers in Georgia (United States). *Climatic Change*, 109(3), pp.791-799. doi:10.1007/s10584-011-0238-y
69. Gibbons, M., 2000. Mode 2 society and the emergence of context-sensitive science. *Sci. Public Policy* 27, 159–163. <https://doi.org/10.3152/147154300781782011>
Gibbons, M., 1999. Science’s new social contract with society. *Nature* 402, 81–84. <https://doi.org/10.1038/35011576>.

70. Gieryn, T.F., 1995. Boundaries of science. In *Science and the Quest for Reality* (pp. 293-332). Palgrave Macmillan, London.
71. Giller, K.E., Leeuwis, C., Andersson, J.A., Andriesse, W., Brouwer, A., Frost, P., Hebinck, P., Heitkonig, I., Van ittersum, M.K., Koning, N., 2008. Competing € Claims on Natural Resources: what Role for Science.
72. Gough, M., & Rosenfeld, J. 2006. Video conferencing over I.P.: Configure, secure, and troubleshoot. Rockland, MA: Syngress
73. Gray, D., 2004. Collecting and analysing qualitative data. *Doing research in the real world*, pp.319-347.
74. Gray, L.M., Wong-Wylie, G., Rempel, G.R. and Cook, K., 2020. Expanding qualitative research interviewing strategies: Zoom video communications. *The Qualitative Report*, 25(5), pp.1292-1301.
75. Guido, Z., Knudson, C., Campbell, D., Tomlinson, J. 2019. Climate information services for adaptation: what does it mean to know the context? *Climate and Development*, (), 1–13. doi:10.1080/17565529.2019.1630352
76. Guston, D.H. 1999 Stabilizing the boundary between U.S. politics and science: The role of the Office of Technology Transfer as a boundary organization. *Soc Stud Sci* 29: 87–111.
77. Guston, D.H. 2001. Boundary organizations in environmental policy and science: An introduction. *Sci Technol Human Values* 26:399–408
78. Hackenbruch, J., Kunz-Plapp, T., Müller, S., Schipper, J., 2017. Tailoring Climate Parameters to Information Needs for Local Adaptation to Climate Change. *Climate* 5, 25. doi.org/10.3390/cli5020025
79. Hammill, A., Tanner, T., 2011. *Harmonising Climate Risk Management: Adaptation Screening and Assessment Tools for Development Co-operation*. OECD Publishing
80. Hammill, A., Harvey, B., and Echeverria, D. 2013. Knowledge for action: an analysis of the use of online climate knowledge brokering platforms. *Knowl. Manag. Dev. J.* 9, 72–92. doi: 10.1093/oso/9780198792154.003.0009

81. Hannah, L., Roehrdanz, P.R., Ikegami, M., Shepard, A.V., Shaw, M.R., Tabor, G., Zhi, L., Marquet, P.A. and Hijmans, R.J., 2013. Climate change, wine, and conservation. *Proceedings of the National Academy of Sciences*, 110(17), pp.6907-6912.
82. Hansen, J. W. 2002. Realising the potential benefits of climate prediction to agriculture: Issues, approaches, challenges. *Agricultural Systems*, 74 (3), 309–330. [https://doi.org/10.1016/S0308-521X\(02\)00043-4](https://doi.org/10.1016/S0308-521X(02)00043-4)
83. Hansen, J. W., Mason, S. J., Sun, L., & Tall, A. 2011. Review of seasonal climate forecasting for agriculture in Sub-Saharan Africa. *Experimental Agriculture*, 47(02), 205–240. doi.org/10.1017/S00144797100 00876
84. Harrison, C., Burgess, J. and Filius, P. 1996, 'Rationalizing Environmental Responsibilities: A Comparison of Lay Publics in the U.K. and the Netherlands', *Global Environmental Change*, vol. 6, no. 3, pp. 215–34. doi:10.1016/0959-3780(96)00016-7
85. Harvey, C.A., Chacón, M., Donatti, C.I., Garen, E., Hannah, L., Andrade, A., Bede, L., Brown, D., Calle et al. 2014. Climate-Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture. *Conservation Letters*, 7(2), 77–90. doi:10.1111/conl.12066
86. Harvey, B., Cochrane, L., Van Epp, M., 2019. Charting co-production pathways in climate and development programming and practice. *Environ. Policy Gov.* 1–11. <https://doi.org/10.1002/eet.1834>
87. Harvey, B., Jones, L., Cochrane, L., and Singh, R. 2019a. The evolving landscape of climate services in sub-Saharan Africa: what roles have NGOs played? *Clim. Change* 157, 81–98. doi: 10.1007/s10584-019-02410-z
88. Harvey, B., Huang, Y.S., Araujo, J., Vincent, K., Roux, J.P., Rouhaud, E. and Visman, E., 2021. Mobilizing climate information for decision-making in Africa: contrasting user-centered and knowledge-centered approaches. *Frontiers in Climate*.
89. Hegger, D., Lamers, M., Van Zeijl-Rozema, A., Dieperink, C., 2012. Conceptualising joint knowledge production in regional climate change adaptation projects: Success conditions and levers for action. *Environ. Sci. Policy* 18, 52–65. <https://doi.org/10.1016/j.envsci.2012.01.002>

90. Hochachka, G., 2021. Finding shared meaning in the Anthropocene: engaging diverse perspectives on climate change.
91. Holling, C.S. 1973 Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4, 1–23.
92. Holloway, L., 1999. Understanding climate change and farming: scientific and farmers' constructions of 'global warming' in relation to agriculture. *Environ. Plan. A* 31, 2017e2032.
93. Howden, S.M., Soussana, J.-F., Tubiello, F.N., Chhetri, N., Dunlop, M., Meinke, H., 2007. Adapting agriculture to climate change. *Proc. Natl. Acad. Sci.* 104, 19691–19696. doi.org/10.1073/pnas.0701890104
94. Ingram, K. T., M. C. Roncoli, and P. H. Kirshen, 2002: Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. *Agric. Syst.*, 74, 331–349.
95. Ingram, J., 2008. Agronomist farmer knowledge encounters: an analysis of knowledge exchange in the context of best management practices in England. *Agric. Hum. Values* 25, 405e418.
96. Ingram, J., Fry, P., Mathieu, A., 2010. Revealing different understandings of soil held by scientists and farmers in the context of soil protection and management. *Land Use Policy* 27, 51e60
97. Ingram, J., Mills, J., Dibari, C., Ferrise, R., Ghaley, Bhim B., Hansen, J. G, Iglesias, A., Karaczun, Z., McVittie, A., Merante, P; Molnar, A., Sánchez, Berta. 2016. Communicating soil carbon science to farmers: Incorporating credibility, salience, and legitimacy. *Journal of Rural Studies*, 48(), 115–128. [doi:10.1016/j.jrurstud.2016.10.005](https://doi.org/10.1016/j.jrurstud.2016.10.005)
98. IPCC. 2007. 'Summary for policymakers', in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. Van der Linden & C.E. Hanson (eds.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
99. IPCC. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* [Field, C.B., V. Barros, T.F. Stocker, D.

Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)). Cambridge University Press, Cambridge, UK, and New York, NY, USA.

100. IPCC. 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
101. IPCC. 2014. Climate Change Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.
102. IPCC. 2014a. Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
103. IPCC. 2018. Special Report on Global Warming of 1.5°C. <https://www.ipcc.ch/sr15/> .
104. Jacob, K., Lebel, L., Buizer, J., Addams, L., Matson, P et al. 2010. Linking knowledge with action in the pursuit of sustainable water-resources management. Proc. Natl. Acad. Sci. USA. In press. doi:10.1073/pnas.0813125107
105. Jagannathan, K.A., 2019. Ready-to-use?-Bridging the climate science-usability gap for adaptation. University of California, Berkeley.
106. Jasanoff, S.S., 1987. Contested boundaries in policy-relevant science. Social studies of science, 17(2), pp.195-230.
107. Jasanoff, S. 1990. The Fifth Branch: Science Advisers as Policymakers. Cambridge, MA: Harvard Univ. Press
108. Jones, L., Champalle, C., Chesterman, S., Cramer, L., and Crane, T. A. 2017. Constraining and enabling factors to using long-term climate information in decision-making. Clim. Policy 17, 551–572. doi: 10.1080/14693062.2016.1191008
109. Jordaan, A. J., Ogundeji, A. A., Nyam, Y. S., Ilbury, C., Turton, T., Walker, S. and van Copenhagen, G.(2021) Scenarios for Future Agricultural Water Management in South Africa. Water Research Commission,WRC No 4/2711, Pretoria

110. Jordaan, A., 2022. Drought: The case of South Africa. In *Routledge Handbook of Environmental Hazards and Society* (pp. 106-124). Routledge.
111. Kaspersen, R.E. 2010. Science and disaster risk reduction. *Int. J. Disaster Risk Sci.* 1:3–9
112. Khalil, R., Mansour, A.E., Fadda, W.A., Almisnid, K., Aldamegh, M., Al-Nafeesah, A., Alkhalifah, A. and Al-Wutayd, O., 2020. The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: a qualitative study exploring medical students' perspectives. *BMC medical education*.
113. Khan, M.R., Roberts, J.T., 2013. Adaptation and international climate policy. *Wiley Interdiscip. Rev. Clim. Chang.* 4, 171–189. doi.org/10.1002/wcc.212
114. Kingdon, J., 1995. *Agendas, alternatives, and public policies*. 2nd ed. New York: Longman.
115. Kiparsky M., Milman A., Vicuna S. 2012. Climate and water: knowledge of impacts to action on adaptation. ~ *Annu. Rev. Environ. Resour.* 37:163–94
116. Kirchhoff C.J., Lemos M.C., Engle N.L. 2012. What influences climate information use in water management? The role of boundary organizations and governance regimes in Brazil and the U.S. *Environ. Sci. Policy* 26:6–18
117. Kirchhoff, C.J., Carmen Lemos, M., Dessai, S., 2013a. Actionable Knowledge for Environmental Decision-Making: Broadening the Usability of Climate Science. *Annu. Rev. Environ. Resour.* 38, 393–414. <https://doi.org/10.1146/annurev-environ022112-112828>
118. Klein R.J.T., Midgley, G.F., Preston, B.L., Alam, M., Berkhout, F.G.H., Dow, K., Shaw, M.R., 2014. 16. Adaptation Opportunities, Constraints, and Limits. *Assess. Rep.* 5- *Clim. Chang. 2014 Impacts, Adapt. Vulnerability. Part A Glob. Sect. Asp.*
119. Klenk, N.L., Meehan, K., Pinel, S.L., Mendez, F., Lima, P.T., Kammen, D.M., 2015. Stakeholders in climate science : Beyond lip service ? *Science* (80-.). 743, 743–744. doi.org/10.1126/science.aab1495
120. Klenk, N., Fiume, A., Meehan, K., Gibbes, C., 2017. Local knowledge in climate 97 adaptation research: moving knowledge frameworks from extraction to coproduction. *Wiley Interdiscip. Rev. Clim. Chang.* 8. <https://doi.org/10.1002/wcc.475>

121. Kotcher, J E., Myers, T A., Vraga, E K., Stenhouse, N., Maibach, E W. 2017. "Does Engagement in Advocacy Hurt the Credibility of Scientists?. Results from a Randomized National Survey Experiment" Environmental Communication Article in Press
122. Kotze, I. and Rose, M., 2015. Farming facts and futures: Reconnecting South Africa's food systems to its ecosystems. Cape Town, South Africa, WWF-SA.
123. Kuschke, I. and Cassim, A., 2019. Sustainable agriculture: market intelligence report. Cape Town, 8001.
124. Latour B. 1998. From the world of science to the world of research? Science 280:208–09 27.
125. Kirchhoff, C.J., Esselman, R., Brown, D., 2015a. Boundary organizations to boundary chains: Prospects for advancing climate science application. Clim. Risk Manag. . doi.org/10.1016/j.crm.2015.04.001
126. Lanari, N. and Bek, D., 2022. More than floods and droughts: Understanding emergent water risks in South African fruit production networks. Area.
127. Leeuwis, C., Leeuwis, C., Ban, A., 2004. Communication for Rural Innovation. Wiley Online Library.
128. Lemos MC, Morehouse B. 2005. The co-production of science and policy in integrated climate assessments. Glob. Environ. Change 15:57–68
129. Lemos, M.C. 2008. What influences innovation adoption by water managers? Climate information use in Brazil and the United States. J. Am. Water Resour. Assoc. (JAWRA) 44:1388–96
130. Lemos,M.C., Bell, A., Engle, N.E., Formiga-Johnsson, R.M., Nelson, D.R. 2010. Technical knowledge and water resources management: a comparative study of river basin councils, Brazil. Water Resour. Res. 46: W06523
131. Lemos, M.C., Rood, R.B., 2010. Climate projections and their impact on policy and practice. Wiley Interdiscip. Rev. Clim. Chang. 1, 670–682. <https://doi.org/10.1002/wcc.71>
132. Lemos M.C., Kirchhoff C.J., Ramparasad V. 2012. Narrowing the climate information usability gap. Nat. Clim. Change 2:789–94

133. Lemos, M.C., Arnott, J.C., Ardoin, N.M., Baja, K., Bednarek, A.T., Dewulf, A., Fieseler, C., Goodrich, K.A., Jagannathan, K., Klenk, N. and Mach, K.J., 2018. To co-produce or not to co-produce. *Nature Sustainability*.
134. Lempert, R.J., Popper, S.W., Groves, D.G., Kalra, N., Fischbach, J.R., Bankes, S.C., Bryant, B.P., Collins, M.T., Keller, K., Hackbarth, A., Dixon, L., LaTourrette, T., Reville, R.T., Hall, J.W., Mijere, C., McInerney, D.J. 2013. *Making Good Decisions Without Predictions: Robust Decision-Making for Planning Under Deep Uncertainty*. Santa Monica, CA.
135. Le Roux, A., Makhanya, S., Arnold, K., Van Tonder, L., Wools, L. and Mans, G. (2019) *Green Book. Projecting the Future Growth of South African Settlements: Developing a Concept Model for Town Growth Forecasting in South Africa*. Technical report, CSIR, Pretoria
136. Li, N., Hilgard, J., Scheufele, D A., Winneg, K M., Jamieson, K H. 2016. "Cross-pressuring conservative Catholics? Effects of Pope Francis' encyclical on the U.S. public opinion on climate change" *Climatic Change* 139(3-4)
137. Long, N., 2001. *Sociology of Development: Actor Perspectives*. Routledge, London. Mackey, B., Prentice, I.C., Steffen, W., House, J.I., Lindenmayer, D., Keith, H., Berry, S., 2013. Untangling the confusion around land carbon science and climate change mitigation policy. *Nat. Clim. Change* 3, 552e557
138. Lotter, J.M., 2015. Potential implications of climate change for Rooibos (*A. linearis*) production and distribution in the greater Cederberg region, South Africa.
139. Luborsky, M.R. and Rubinstein, R.L., 1995. Sampling in qualitative research: Rationale, issues, and methods. *Research on aging*, 17(1)
140. Luedeling, E., Brown, P.H. 2011. A global analysis of the comparability of winter chill models for fruit and nut trees. *Int. J. Appl. Earth Obs. Geoinf.*
141. Mach, K. J., Lemos, M. C., Meadow, A. M., Wyborn, C., Klenk, N., Arnott, J. C., et al. (2020). Actionable knowledge and the art of engagement. *Curr. Opin. Env. Sus.* 42, 30–37. doi: 10.1016/j.cosust.2020.01.002
142. Macnaghten, P. and Jacobs, M., 1997. Public identification with sustainable development: investigating cultural barriers to participation. *Global Environmental Change*, 7(1), pp.5-24.
143. McKenzie-Mohr, D. and Smith, W., 1999. *Fostering sustainable behavior: An introduction to community-based social marketing*. Gabriola Island. British Columbia, Canada: New Society, 27.

144. McNie, E.C., 2007. Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. *Environ. Sci. Policy* 10, 17– 38. <https://doi.org/10.1016/j.envsci.2006.10.004>
145. McNie, E.C., 2012. Delivering climate services: organizational strategies and approaches for producing useful climate-science information. *Weather Clim. Soc.* 5, 14–26. doi: 10.1175/WCAS-D-11-00034.1
146. Mase, A.S., & Prokopy, L.S. 2014. Unrealized potential: A review of perceptions and use of weather and climate information in agricultural decision making. *Weather, Climate, and Society*, 6(1), 47–61. doi:10. 1175/WCAS-D-12-00062.1
147. Meadow, A.M., Ferguson, D.B., Guido, Z., Horangic, A., Owen, G., Wall, T., 2015. Moving toward the Deliberate Coproduction of Climate Science Knowledge. *Weather. Clim. Soc.* 7, 179–191. <https://doi.org/10.1175/WCAS-D-14-00050.1>
148. Meijer, S.S, Catacutan, D., Ajayi, O.C., Sileshi, G.W. & Nieuwenhuis, M. 2014: The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa, *International Journal of Agricultural Sustainability*, DOI: 10.1080/14735903.2014.912493. <http://dx.doi.org/10.1080/14735903.2014.912493>
149. Midgley, G.F., Chapman, R.A., Hewitson, B., Johnston, P., de Wit, M., Ziervogel, G., Mukheibir, P., van Niekerk, L., Tadross, M., van Wilgen, B.W., Kgope, B., Morant, P.D., Theron, A., Scholes, R.J., Forsyth, G.G. 2005. A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape. Report to the Western Cape Government, Cape Town, South Africa. CSIR Report No. ENV-S-C 2005-073, Stellenbosch.
150. Midgley, S.J.E. & Lötze, E. 2011. Climate Change in the Western Cape of South Africa: Trends, Projections, and Implications for Chill Unit Accumulation. *Proceedings of the 9th International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems*, August 2008, Geneva NY, USA, *Acta Horticulturae* 903: 1127-1134.
151. McCrudden, M T., Stenseth, T., Bråten, I., Strømsø, H.I. 2016. The effects of topic familiarity, author expertise, and content relevance on Norwegian students' document selection: A mixed methods study” *Journal of Educational Psychology* 108(2): 147-162
152. Midgley, S. and Methner, N., 2016; Climate Adaptation Readiness for Agriculture: Drought Lessons from the Western Cape, South Africa.

153. Miller, C. 2001. Hybrid management: boundary organizations, science policy, and environmental governance in the climate regime. *Science Technology and Human Values*, 26(4), 478–500.
154. Moser, S.C. 2010. Communicating climate change: History, challenges, process and future directions. *Wiley Interdisciplinary Reviews: Climate Change*, 1(1), 31–53.
155. Mote, P., Brekke, L., Duffy, P.B., Maurer, E., 2011. Guidelines for constructing climate scenarios. *Eos* (Washington. D.C.). 92, 257–264. <https://doi.org/10.1029/2011EO310001>
156. Mudombi, S., & Nhamo, G. 2014. Access to weather forecasting and early warning information by communal farmers in Seke and Murewa Districts, Zimbabwe. *Journal of Human Ecology*, 48(3), 357–366. <https://doi.org/10.1080/09709274.2014.11906805>
157. Murunga, M., Pecl, G., Ogier, E., Leith, P., Macleod, C., Kelly, R., Corney, S., van Putten, I., Mossop, D., Cullen-Knox, C. and Bettiol, S., 2022. More than just information: what does the public want to know about climate change? *Ecology and Society*, 27(2).
158. Neef, A., Neubert, D., 2011. Stakeholder participation in agricultural research projects: a conceptual framework for reflection and decision-making. *Agric. Hum. Values* 28, 179e194.
159. New, M., Hewitson, B., Stephenson, D.B., Tsiga, A., Kruger, A., Manhique, A., Gomez, B., Coelho, C.A.S., Masisi, D.N., Kululanga, E., et al. Evidence of trends in daily climate extremes over southern and west Africa. *J. Geophys. Res. Atmos.* 2006, 111, 1–11.
160. Nesamvuni, E., Lekalakala, R., Norris, D., Ngambi, J. W. 2012. Effects of climate change on dairy cattle, South Africa. *African Journal of Agricultural Research*. 7(26):3867-72.
161. Nhamo, L., Ndelela, B., Nhemachena, C., Mabhaudhi, T., Mpandeli, S and Matchaya, G. (2018), The Water-Energy-Food Nexus: Climate Risks and Opportunities in Southern Africa. *Water* **2018**, 10, 567. <https://doi.org/10.3390/w10050567>
162. Nhemachena, C., Nhamo, L., Matchaya, G., Nhemachena, C. R., Muchara, B., Karuaihe, S. T., & Mpandeli, S. 2020. Climate Change Impacts on Water and Agriculture Sectors in Southern Africa: Threats and Opportunities for Sustainable Development. *Water*, 12(10), 2673. doi:10.3390/w12102673

163. Niang, I., Ruppel, O.C., Abdrabo, M.A., Essel, A., Lennard, C., Padgham, J. and Urquhart, P. 2014. Africa. In: Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and White, L.L., Eds., *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, 1199-1265.
164. Nicholas, K.A., Durham, W.H., 2012. Farm-scale adaptation and vulnerability to environmental stresses: Insights from winegrowing in Northern California. *Glob. Environ. Chang.* 22, 483–494. <https://doi.org/10.1016/j.gloenvcha.2012.01.00>
165. Nissan, H., Goddard, L., de Perez, E.C., Furlow, J., Baethgen, W., Thomson, M.C., Mason, S.J., 2019. On the use and misuse of climate change projections in international development. *Wiley Interdiscip. Rev. Clim. Chang.* e579. <https://doi.org/10.1002/wcc.579>
166. Nkhata, B. 2020. *Climate Change and Water Resources in Southern Africa: A Resilience Perspective*. Springer Nature Switzerland AG 2020R. Brears (ed.), *The Palgrave Handbook of Climate Resilient Societies*, https://doi.org/10.1007/978-3-030-32811-5_98
167. OECD, 2009. *Managing Risk in Agriculture. A holistic approach*. The full text of this book is available here: www.sourceoecd.org/agriculture/9789264075306
168. Oettle, N. 2006. ‘Farming on the edge’ in arid western South Africa: adapting to climate change in marginal environments. Manuscript. WWF-SA Climate Change Program.
169. Ogar, E., G. Pecl, & T. Mustonen. 2020. Science must embrace traditional and indigenous knowledge to solve our biodiversity crisis. *One Earth* 3(2):162-165. <https://doi.org/10.1016/j.oneear.2020.07.006>
170. Oliver, D.M., Fish, R.D., Winter, M., Hodgson, C.J., Heathwaite, A.L., Chadwick, D.R., 2012. Valuing local knowledge as a source of expert data: farmer engagement and the design of decision support systems. *Environ. Model. Softw.* 36, 76e85
171. Olsson, P., Folke, C., and Hahn, T. 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society* 9(4): 2. [online] URL: <http://www.ecologyandsociety.org/vol9/iss4/art2/>

172. Opiyo, F., Wasonga, O., Nyangito, M., Schilling, J. and Munang, R., 2015. Drought adaptation and coping strategies among the Turkana pastoralists of northern Kenya. *International Journal of Disaster Risk Science*.
173. Otto, F. E. L., Wolski, P., Lehner, F., Tebaldi, C., van Oldenborgh, G. J., Hogesteeger, S., New, M. 2018. Anthropogenic influence on the drivers of the Western Cape drought 2015–2017. *Environmental Research Letters*, 13(12), 124010. doi:10.1088/1748-9326/aae9f9
174. Otto, F. E. L. et al. 2018. Likelihood of Cape Town water crisis tripled by climate change. *World Weather Attribution* <https://www.worldweatherattribution.org/the-role-of-climate-change-in-the-2015-2017-drought-in-the-western-cape-of-south-africa/> (2018).
175. Owusu, V., Ma, W., Renwick, A., Emuah, D., 2020. Does the use of climate information contribute to climate change adaptation? Evidence from Ghana. *Climate and Development*, (), 1–14. doi:10.1080/17565529.2020.1844612
176. Pannell D., Marshall G., Barr N., Curtis A., Vanclay F., Wilkinson R. 2006. Understanding and promoting adoption of conservation practices by rural landholders, *Aust. J. Exp. Agr.* 46, 1407–1424.
177. Pearman, O. & Cravens, A.E., 2022. Institutional barriers to actionable science: Perspectives from decision support tool creators. *Environmental Science & Policy*, 128, pp.317-325.
178. Pasquini, L., 2019. The urban governance of climate change adaptation in least-developed African countries and in small cities: the engagement of local decision-makers in Dar es Salaam, Tanzania, and Karonga, Malawi. *Climate and Development*, 12(5), pp.408-419. doi:10.1080/17565529.2019.1632166
179. Patt, A., Suarez, P. and Gwata, C., 2005. Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe. *Proceedings of the National Academy of Sciences*, 102(35), pp.12623-12628.
180. Pellizzoni, L. 2010. Environmental knowledge and deliberative democracy. In *Environmental Sociology: European Perspectives and Interdisciplinary Challenges*, ed. M Gross, H Heinrichs, pp. 159–83. London, UK: Springer
181. Popoola, O. O., Yusuf, S. F. G., & Monde, N. 2020. Information Sources and Constraints to Climate Change Adaptation amongst Smallholder Farmers in Amathole District Municipality, Eastern Cape Province, South Africa. *Sustainability*, 12(14), 5846.

182. Porter, J.J., Dessai, S., 2017. Mini-me: Why do climate scientists' misunderstand users and their needs? *Environ. Sci. Policy* 77, 9–14. doi.org/10.1016/j.envsci.2017.07.004
183. Potter E., Oster C. 2008. Communicating climate change: public responsiveness and matters of concern, Media international Australia, incorporating culture and policy, no. 127, pp. 116-126.
184. Prokopy, L. S.; Arbuckle, J. G.; Barnes, A. P.; Haden, V. R.; Hogan, Anthony; Niles, Meredith T.; Tyndall, J. 2015. Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries. *Environmental Management*, 56(2), 492–504. doi:10.1007/s00267-015-0504-2
185. Rashid, Y., Rashid, A., Warraich, M.A., Sabir, S.S. and Waseem, A., 2019. Case study method: A step-by-step guide for business researchers. *International journal of qualitative methods*, 18, p.1609406919862424.
186. Raymond, C.M. and Robinson, G.M., 2013. Factors affecting rural landholders' adaptation to climate change: Insights from formal institutions and communities of practice. *Global Environmental Change* 23: 103–114.
187. Reason, C.J.C & Rouault, M. 2005. Links between the Antarctic Oscillation and winter rainfall over western South Africa. *Geophysical Research Letters*, 32(7). doi: 10.1029/2005GL022419.
188. Reinecke, S. 2015. Knowledge brokerage designs and practices in four European climate services: A role model for biodiversity policies? *Environmental Science and Policy* 54: 513-521
189. Riley, M., 2008. Experts in their fields: farmer expert knowledges and environmentally friendly farming practices. *Environ. Plan. A* 40, 1277e1293.
190. Riessman, C. K. 2005. Narrative Analysis. In: *Narrative, Memory & Everyday Life*. University of Huddersfield, Huddersfield, pp. 1-7.
191. Robert, M., Thomas, A. and Bergez, J.E., 2016. Processes of adaptation in farm decision-making models. A review. *Agronomy for sustainable development*, 36(4), pp.1-15.
192. Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K.T., Woodin, M., Somé, L., Ouattara, F., Sanfo, B.J., Sia, C., Yaka, P., Hoogenboom, G., 2009. From accessing to assessing forecasts: An end-to-end study of participatory climate forecast dissemination in Burkina Faso (West Africa). *Clim. Change* 92, 433–460. <https://doi.org/10.1007/s10584-008-9445-6>

193. Ross, D.W & White, D. 2019. Building Tools at the Boundary of Climate Science, Security, and Action. <https://www.newamerica.org/resource-security/natural-security-blog/building-tools-boundary-climate-science-security-and-action/>
194. Rust, J.M. & Rust, T., 2013, Climate change and livestock production: A review with emphasis on Africa', South African Journal of Animal Science 43(3). <https://doi.org/10.4314/sajas.v43i3.3>.
195. Sarku, R., Van Slobbe, E., Termeer, K., Kranjac-Berisavljevic, G. and Dewulf, A., 2022. Usability of weather information services for decision-making in farming: Evidence from the Ada East District, Ghana. *Climate Services*, 25, p.100275.
196. Scholz, G. & Methner, N., 2020. A social learning and transition perspective on a climate change project in South Africa. *Environmental Innovation and Societal Transitions*, 34, pp.322-335.
197. Schulze, R., Lumsden, T., Horan, M., Warburton, M. and Wand, S., 2007. Projected Impacts: Agriculture.
198. Shew, A.M., Tack, J.B., Nalley, L.L. and Chaminuka, P., 2020. Yield reduction under climate warming varies among wheat cultivars in South Africa. *Nature communications*, 11(1), pp.1-9.
199. Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M. & Kituyi, E. 2017. The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. *Climate and Development*. Available: <http://dx.doi.org/10.1080/17565529.2017.1318744>.
200. Sleeth-Keppler, D., Perkowitz, R., Speiser, M. 2017. It's a Matter of Trust: American Judgments of the Credibility of Informal Communicators on Solutions to Climate Change. *Environmental Communication* 11(1):17-40.
201. Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity, and vulnerability 16, 282–292. <https://doi.org/10.1016/j.gloenvcha.2006.03.008>.
202. Sturges, J.E. and Hanrahan, K.J., 2004. Comparing telephone and face-to-face qualitative interviewing: a research note. *Qualitative research*, 4(1), pp.107-118.
203. Soubry, B., Sherren, K, Thornton, T. F. 2019. Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007–2018. *Journal of Rural Studies*, (), S0743016718313743–. doi:10.1016/j.jrurstud.2019.09.005 .
204. Sumberg, J., Thompson, J., Woodhouse, P., 2013. Why agronomy in the developing world has become contentious. *Agric. Hum. Values* 30, 71e83.

205. Swart, R.J., et al. Developing climate information portals with users: Promises and pitfalls. *clim. Ser.* (2017), <http://dx.doi.org/10.1016/j.cliser.2017.06.008>
206. Talanow, K.T., Emmeline N., Loos, J., MartÃn-LÃpez, Berta. 2020. Farmers' perceptions of climate change and adaptation strategies in South Africa's Western Cape. *Journal of Rural Studies*, (), S0743016720304678–. doi:10.1016/j.jrurstud.2020.10.026 Tang, S., Dessai, S. 2012. Usable science? The U.K. climate projections 2009 and decision support for adaptation planning. *Weather Clim. Soc.* 4:300–13.
207. Tarnoczi, T.J, Berkes, F. 2010. Sources of information for farmers' adaption practices in Canada's Prairie agroecosystem. *Clim Change* 98:299–305.
208. Taylor, A.L., Dessai, S., & de Bruin, W.B. 2015. Communicating uncertainty in seasonal and interannual climate forecasts in Europe. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*, 373(2055), 20140454. doi:10.1098/rsta.2014. 0454.
209. Tharaga, P.C., Steyn, A.S. and Coetzer, G.M., 2021. Climate Change Impacts on Temperature and Chill Unit Trends for Apple (*Malus domestica*) Production in Ceres, South Africa. *Atmosphere*, 12(6), p.740.
210. Theron, H. & Hunted, J.J., 2022. Mitigation and Adaptation Practices to the Impact of Climate Change on Wine Grape Production, with Special Reference to the South African Context. *South African Journal of Enology and Viticulture*, 43(1), pp.10-25.
211. Theron, S.N., Archer, E., Midgley, S.J.E. and Walker, S., 2021. Agricultural perspectives on the 2015-2018 western cape drought, South Africa: Characteristics and spatial variability in the core wheat growing regions. *Agricultural and Forest Meteorology*, 304, p.108405.
212. Toth,F.L. ; Hiznyik,E., Integrated environmental assessment methods: evolution and application *Environental Modelling and Assessment*, volume 3, p. 193 – 207.
213. Trautmann,I. 2017. Agriprobe. SMARTAGRI – Putting the plan into action. A short progress report. <https://hdl.handle.net/10520/EJC-be10ff3c0>.
214. Twongyirwe, R., Sheil, D., Sandbrook, C G., Sandbrook, L C. 2015. REDD at the crossroads? The opportunities and challenges of REDD for conservation and human welfare in South West Uganda. *International Journal of Environment and Sustainable Development* 14(3): 273-298.

215. United Nations Food and Agriculture Organisation (FAO), 2020. Conservation Agriculture in Southern Africa Factsheet. Building partnerships for climate resilience Rome: Food and Agriculture Organization of the United Nations.
216. Vanclay, F., 1992. Barriers to adoption: a general overview of the issues. *Rural Society*, 2(2), pp.10-12.
217. VanderMolen, K., Wall, T.U. and Daudert, B., 2019. A call for the evaluation of web-based climate data and analysis tools. *Bulletin of the American Meteorological Society*, 100(2).
218. Van Kerkhoff, L., Lebel, L. 2006. Linking knowledge and action for sustainable development. *Annu. Rev. Environ. Resour.* 31:445–77
219. Vano, J.A., Miller, K., Dettinger, M.D., Cifelli, R., Curtis, D., Dufour, A., Olsen, J.R., Wilson, A.M., 2019. Hydroclimatic Extremes as Challenges for the Water Management Community: Lessons from Oroville Dam and Hurricane Harvey. *Bull. Am. Meteorol. Soc.* 100, S9--S14.
220. Vaughan, C., Buja, L., Kruczkiewicz, A., and Goddard, L. 2016. Identifying research priorities to advance climate services. *Clim. Serv.* 4, 65–74. doi: 10.1016/j.cliser.2016.11.004.
221. Vincent, K., Dougill, A. J., Dixon, J. L., Stringer, L. C., and Cull, T. 2017. Identifying climate services needs for national planning: insights from Malawi. *Clim. Policy* 17, 189–202. doi: 10.1080/14693062.2015.1075374
222. Vincent, K., Conway, D., Dougill, A. J., Pardoe, J., Archer, E., Bhave, A. G., et al. 2020b. Re-balancing climate services to inform climate-resilient planning – a conceptual framework and illustrations from sub-Saharan Africa. *Clim. Risk Man.* 29:100242. doi: 10.1016/j.crm.2020.100242
223. Vink, N. and Kirsten, J., 2003. Policy successes and policy failures in agriculture and land reform in South Africa the 1990s. *South African Journal of Economic History*, 18(1-2), pp.96-117.
224. Vogel, C., & O'Brien, K. 2006. Who can eat information? Examining the effectiveness of seasonal climate forecasts and regional climate-risk management strategies. *Climate Research*, 33(1), 111–122. <https://doi.org/10.3354/cr033111>
225. Vogel, J.M., Smith, J.B., O'Grady, M., Flemming, P., Heyn, K., Adams, A., Pierson, D., Brooks, K., Behar, D., 2015. Actionable Science in Practice: Co-producing Climate Change Information for Water Utility Vulnerability Assessments

226. Vogel, J., Mcnie, E., Behar, D., 2016. Co-producing actionable science for water utilities. *Clim. Serv.* 2–3, 30–40. <https://doi.org/10.1016/j.cliser.2016.06.003>
227. Wallace, M. 2014. 'Modelling the impact of future climate change on sub-regional wheat production in the Western Cape'. Presentation, CSAG Seminar, 28 February 2014.
228. Wallington, T.J, Maclean,K. , Darbas,T., Robinson,C.J. 2010. Knowledge—action systems for integrated water management: national and international experiences, and implications for southeast Queensland. *Water Secur. Res. Alliance Tech. Rep. No. 29*, City East, QLD, Aust
229. Wand, S.J.E., Steyn, W. J., and Theron, K. I. 2008a. Vulnerability and impact of climate change on pear production in South Africa. *Acta Hort.* 800: 263–271.
230. Western Cape Agristats Dataset, 2018. Western Cape Department of Agriculture. <http://www.elsenburg.com/gis/apps/agristats/>
231. Western Cape Government (WCG), 2016a. Status Quo Review of Climate Change and Agriculture in the Western Cape Province.
232. Western Cape Government (WCG), 2016b. Western Cape Climate Change Response Framework and Implementation Plan for the Agricultural Sector – 2016.
233. Western Cape Department of Economic Development and Tourism. 2014. Annual Report 2013-2014. Cape Town: Government Printing Works.
234. Western Cape Government. 2014. Western Cape climate change response strategy.
235. Western Cape Government. 2015. A Status Quo Review of Climate Change and the Agricultural Sector of the Western Province – A Brief for the Deciduous Fruit Sector. <https://www.greenagri.org.za/assets/documents-/SmartAgri/Briefs-/9-Brief-for-the-Deciduous-Fruit-sector.pdf>
236. Western Cape Government. 2015. A Status Quo Review of Climate Change and the Agricultural Sector of the Western Province – A Brief for Grain and Livestock sector, Swartland and Greater West Coast Region.
237. Western Cape Government. 2015. A Status Quo Review of Climate Change and the Agricultural Sector of the Western Province – A Brief for Grain and the Livestock Sector, Ruens. Accessed on <https://www.greenagri.org.za/assets/documents-/SmartAgri/Briefs-/2-Brief-for-the-Grain-and-Livestock-sector-Ruens.pdf>

238. Western Cape Government. 2015. A Status Quo Review of Climate Change and the Agricultural Sector of the Western Province – A Brief for the Rooibos Sector, Central Karoo. Accessed on <https://www.greenagri.org.za/assets/documents-/SmartAgri/Briefs-/11-Brief-for-the-Rooibos-sector.pdf>
239. Western Cape Government. 2015/2016. Western Cape Climate Change Response Strategy. Biennial Monitoring and Evaluation Report ('M&E').
240. Western Cape Government. 2017. Informing the Western Cape agricultural sector on the 2015-2017 drought. Western Cape Government: Drought Fact Sheet.
241. Western Cape Government. 2018a. Western Cape Climate Change Response Strategy, 2nd Biennial Monitoring & Evaluation Report ('M&E'), Department of Environmental Affairs and Development Planning, Climate Change Directorate.
242. Western Cape Government. 2018d. Literature Review Assessing Climate Change Risks and Impacts on the Health Sector, in the Western Cape, South Africa. Cape Higher Education Consortium & Western Cape Government Joint Research Programme.
243. Western Cape Government. 2020. Western Cape Climate Change Response Strategy: 3rd Biennial Monitoring & Evaluation Report 2019/20.
244. Western Cape Veterinary Services. 2011. Veterinary services western cape: Animal health (Annual Report. Western Cape Province: Western Cape Government.
245. White, D. D, Wutich, A., Larson, K. L, Gober, P., Lant, T., Senneville, C., 2010. Credibility, salience, and legitimacy of boundary objects: water managers' assessment of a simulation model in an immersive decision theater. 37(3), 219–232. doi:10.3152/030234210x497726
246. Wilson, R.S., Herziger, A., Hamilton, M. and Brooks, J.S., 2020. From incremental to transformative adaptation in individual responses to climate-exacerbated hazards. *Nature Climate Change*, 10(3)
247. Winter, K., Bottaro, J., & Oelofse, C. 2001. Oxford intermediate atlas of Southern Africa. Cape Town: Oxford University Press.
248. Wittmann, E., and Baylis, M. 2000. Climate change: Effects on culicoides-transmitted viruses and implications for the U.K. *The Veterinary Journal*, 160(2)
249. Wong-Parodi, G., Mach, K.J., Jagannathan, K., Sjostrom, K.D., 2020. Insights for developing effective decision support tools for environmental sustainability. *Curr. Opin. Environ. Sustain.*

250. World Bank. 2013a. Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC: World Bank.
251. World Health Organisation, 2020. Coronavirus disease (COVID-19) Weekly Epidemiological Update Data as received by WHO from national authorities, as of 10 am CEST 6 September 2020. <https://www.who.int/publications/m/item/weekly-epidemiological-update---7-september-2020>
252. Wynne, B., 1996. A reflexive view of the expert-lay knowledge divide. Risk, environment, and modernity: Towards a new ecology, 40, p.44.
253. Yin, R. Case Study Research-Design and Methods 3rd ed., Applied Social Research Methods Series. (5) Sage Publications. Thousand Oaks. 2003.
254. Young, A.L., Komlodi, A., Rózsa, G. and Chu, P., 2016. Evaluating the credibility of English web sources as a foreign-language searcher. Proceedings of the Association for Information Science and Technology, 53(1), pp.1-9
255. Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z. and Wei, L., 2020. Multi-agency report highlights increasing signs and impacts of climate change in atmosphere, land, and oceans.
256. Zwane, E.M., 2019, Impact of climate change on primary agriculture, water sources and food security in Western Cape, South Africa. Jàmbá: Journal of Disaster Risk Studies 11(1), a562. <https://doi.org/10.4102/jamba.v11i1.562>