Gordon Institute of Business Science
University of Pretoria

Climate-responsive innovation in agro-processing SMEs

20827840

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Abstract

This study explored whether and how small and medium enterprises (SMEs) in the South African agro-processing industry are innovating in response to climate change, as well as how they could be empowered to innovate even more. This is an important topic because although the business community and academia have good understanding of how climate change affects agriculture, less is known about its effects higher up in the food value chain, or how to address them.

The research findings indicate that agro-processing SMEs are already experiencing increased difficulty in sourcing inputs, due to climatic changes. On the positive side, some parts of South Africa are experiencing an increase in rainfall and thus greater availability of some of the inputs needed by agro-processing SMEs. Nonetheless, industry bodies in the agro-processing sector have a very important role of conducting and disseminating research to guide their members on the climatic changes they should expect, and how to innovate in order to remain viable. Governmental agencies that support SME development also ought to incorporate climate change preparedness into the advisory services they provide to agro-processing SMEs.

The key finding of this qualitative study was that under the changing climate, agro-processing SMEs can only survive and growth through increased innovation. Innovation is fostered by an enabling ecosystem. For agro-processing entrepreneurs to remain viable under the changing climate, they ought to partner with larger corporates in their sector, the research community, industry bodies, financial services providers and government, to access the knowledge, resources and networks needed to foster innovation. These organisations could come together to formalise an innovation ecosystem, to the benefit of all participants and society at large.

It is recommended that society ought to prepare for escalating food prices as food manufacturers experience more difficulty sourcing inputs of the quantity and quality needed. Furthermore, there is a risk that some entrepreneurs might abandon their agro-processing businesses in favour of less climate-sensitive endeavours, leading to food shortages. Society also ought to prepare to make dietary changes as the climate becomes less favourable for the current preferred foods. These are important considerations for food security and the broader economy.

Key terms

climate change response, climate innovation, innovation ecosystem, small and medium enterprises

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Student number: 20827840

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1. Introduction to the research problem

1.1 Introduction

The effects of climate change on business are increasingly apparent; it is essential for companies in climate-sensitive sectors to take responsive action (Todaro et al., 2020). This study advances the debate over innovation for climate change response by exploring how companies in the agro-processing industry are navigating mounting pressure to navigate the impact of environmental volatility. The study foregrounds sustainability concerns in an emerging market context by capturing qualitative data from small and medium enterprises (SMEs) in South Africa.

This chapter introduces the concepts of innovation and climate change and how they manifest in the context of SMEs in agro-processing. The nascent construct of climate innovation is introduced as articulated in the small but growing body of literature on the topic. The subsequent chapter delves into the literature around the concepts, construct and context, in accordance with the research questions.

1.2 Problem statement

The adverse impacts of climate change on businesses are becoming increasingly notable, especially in sectors that are sensitive to climate variations, such as agro-processing. This necessitates both public and private investment in *climate change adaptation*. The Intergovernmental Panel on Climate Change (IPCC), the leading global body of climate science experts, defines adaptation as “the process of adjustment to actual or expected climate and its effects on human systems, in order to moderate harm or exploit beneficial opportunities” (IPCC, 2012, p. 556). Climate change adaptation can also be defined as intentional interventions undertaken to reduce current impact and future risk associated with climate change, to safeguard human and natural systems (Pearce-Higgins et al., 2022).

Relatedly, *climate change mitigation*, which the IPCC (2012) defines as “human interventions to reduce the sources or enhance the sinks of greenhouse gases” (p. 561), alternatively defined as technological change that reduces resource input and/or the quantity of greenhouse gases emitted per unit of output (Boucher et al., 2014), is equally pertinent. Both adaptation and mitigation require innovation,

because climate change cannot be addressed using the same technologies that have caused it. This report refers to climate change adaptation and mitigation as components of *climate change response*, because integrated responses that link the two are necessary to address the climate challenge (Lee, Yang & Blok, 2020). Both in academia and policy, mitigation and adaptation have largely been dichotomised (Pollo & Trane, 2021). At the level of an individual business, where decisions are based on what is most practical and cost-effective, this dichotomy is less useful. Moreover, it is increasingly apparent that most mitigation actions have adaptation co-benefits, and vice-versa (Lee, Yang & Blok, 2020).

In an effort to support climate change response in low-income countries, high-income countries are mandated by the United Nations Framework Convention on Climate Change (UNFCCC) to provide financial support to low-income countries for their climate change response initiatives. (United Nations, 1992). The Convention calls for participatory, multi-level climate change response (Alaye, 2023). Under the 2015 Paris Agreement, high-income countries committed to annually contribute 100 billion USD for projects and programmes addressing climate change in low- and middle-income countries (UNFCCC, 2016). There has been progress towards this target, but it has yet to be met.

According to the Organisation for Economic Cooperation and Development (OECD), the amount of climate response financing provided by high-income countries has been rising yearly since 2016, and in 2021 amounted to 89.6 billion USD. But only 27% of the financing was for adaptation projects and programmes, with the bulk allocated to mitigation projects and programmes, mostly in renewable energy (OECD, 2023). Even if the 100 billion USD per year goal was met, it would still fall far short of the one trillion USD per year that developing countries need for climate response investments (OECD, 2023). The shortfall must be met by developing countries' own public and private sectors (Adhikari & Chalkasra, 2023).

1.3 Purpose statement

This study explored innovation in response to climate change, by SMEs in the South African agro-processing industry. It is important to investigate this subject matter because of its implications for food security (Durán-Sandoval et al., 2023). The literature on this subject shows that the research community has a good

understanding of how climate change affects agriculture (Zilberman et al., 2018), but less about the full extent of upstream and downstream effects on the food value chain (Farooq et al., 2022).

There is a risk that food prices will continue to escalate as food manufacturers experience more difficulty sourcing inputs due to climate change (Durán-Sandoval et al., 2023), or potentially abandon agro-processing businesses in favour of less climate-sensitive ventures, leading to food shortages. Society also ought to embrace dietary changes towards drought-resistant crops, as some of the more water-intensive crops that form the basis of current dietary preferences become more difficult to grow in altered environments (Zurek et al., 2022). These are important considerations for the viability of the food and beverage sector's contribution to the South African economy.

Impacts on food security can be minimised if businesses in the agro-processing industry take innovative action to respond to climate change (Durán-Sandoval et al., 2023). This requires investment in research and development of climate-resilient products, processes and value chains. Various antecedents to private investment in climate change response have been proposed in literature, including internal antecedents within a company, and external antecedents that create an enabling environment.

Crick, Gannon, Diop and Sow (2018) propose internal antecedents as being prior or current experiences of climate change effects. These include having a dedicated climate change response advocate within the company, as well as other employees with expertise and skills relevant to climate change response. External antecedents incorporate legislative and regulatory measures aimed at driving climate change response in the private sector. This includes incentive frameworks designed to engage businesses in climate change response, and market forces that generate new opportunities for private involvement in climate change response (Crick, Gannon et al., 2018).

This study intended to answer the following overarching research question: *What operating environment is needed for agro-processing SMEs to innovate more in response to climate change?* To answer this question, innovation for climate change response was analysed through a risk management lens, to explore different ways in which SMEs respond to climate-induced risk. The study focused on SMEs

because, unlike larger publicly-listed companies, they are not subject to sustainability and climate reporting requirements (Sage, 2023) and are therefore less likely to have a clear process for tracking climate-related risks and opportunities. Furthermore, the study explored future climate change-induced risks and opportunities that SMEs foresee, so as to propose the means necessary to spur further climate-responsive innovation in this category of companies.

The overarching research question was answered through conducting research to answer the following four subsidiary questions, and then integrating the findings:

1. What climate impacts are agro-processing SMEs in South Africa experiencing?

2. How are agro-processing SMEs innovating in response to the changing climate?

3. What risks arising from climate change do agro-processing SMEs identify?

4. What opportunities arising from climate change do agro-processing SMEs identify?

Agro-processing was selected as the focal industry, due to the wide range of options available to these companies in responding to climate change, from product innovation to process modification, as well as supply chain adjustment. Fostering innovation could also contribute towards meeting the sustainable development goals, to which South Africa is committed. In particular, Goal 2 on “ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture” is a direct focus. So too is Goal 9 on “building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation”. Goal 12 on “ensuring sustainable production and consumption patterns”, as well as Goal 13 on “taking urgent action to combat climate change and its impacts” (United Nations, 2015, p.14) are also in scope.

1.4 Research context

This study was undertaken within agro-processing SMEs that produce food and beverages, in South Africa. According to the Department of Trade, Industry and Competition (DTIC) of South Africa, agro-processing refers to the sub-sector of the manufacturing sector that changes the form of primary materials or intermediate products from agriculture, fisheries and forestry (DTIC, 2022). The agro-processing industry is the biggest component of the South African manufacturing sector,

producing one-third of the country's manufactured output (Chitonge, 2021). It comprises a mix of large and small companies. The food and beverage manufacturing industry is a subset of the agro-processing industry, which also includes the timber, textiles, rubber and leather industries (Chitonge, 2021), to cite a few examples.

The World Bank classifies South Africa as an upper middle-income country, with a gross domestic product of approximately 6,767 USD per-capita in 2022 (World Bank, n.d.). The country has both sub-tropical and temperate climatic conditions in different parts, with January being its warmest and rainiest month, and July its coolest and driest (South African Weather Service, 2017).

Despite being one of the most water-stressed countries in the world (Kuzma et al., 2023), South Africa is a major producer of food and beverages, and exports both fresh and processed foods and beverages across Africa and beyond. For example, the country is the second largest exporter of citrus fruit by value, globally (Observatory of Economic Complexity, 2024, February 12), and seventh largest producer of wine by volume (Thatch, 2023).

Evidently, agro-processors in the country have the benefit of a diverse producer community from which to source inputs for production. However, regional variations in climate and landscape across the country make some agricultural regions less productive than others.

1.5 Research scope

This study captured data from respondents in the food and beverage manufacturing industry only. This ensured narrowed focus into this subset of the diverse agro-processing universe of operators.

This study focused on the SME component of the agro-processing industry because most of the larger companies in the industry are publicly-listed companies and are therefore required to monitor and report on their environmental performance, as well as potential environmental impacts on their business viability. SMEs have no such reporting requirements, and might therefore be less aware of environmental threats to their business, such as climate change.

1.6 Business and academic relevance

To safeguard businesses and communities against negative impacts of climate change, it is estimated that global investment in adaptation of 1.8 trillion USD is needed from 2020 to 2030, in five key areas, namely, “climate information and early warning systems, climate-proofing of infrastructure, dryland agriculture, mangrove protection and restoration, and water resources management” (Tall et al., 2021, p.7). It is projected that this investment could yield four times as much in total benefits, including avoided loss and damage (Tall et al., 2021). Private entities, along with the public, stand to gain from these benefits, hence the necessity for contributions from all sectors towards these investments.

As South Africa is a major manufacturer and exporter of processed food and beverages (Chitonge, 2021), climate-induced decline in agricultural production will not only impact local but regional food security, affecting the entire Southern African region. Agro-processors in the country would experience the direct impact of declining agricultural output, through intensified scarcity of ingredients for production. Thus, innovation is needed in the agro-processing industry so as to overcome the effects of dwindling input availability.

This study focuses on the SME component of the agro-processing industry. This is because most of the larger companies in the industry are publicly-listed and therefore required to monitor and report on environmental performance, as well as potential environmental impacts on business viability. SMEs have no such reporting requirements, and therefore be less aware of environmental threats to business, such as climate change.

The importance of agro-processing SMEs’ contribution to food security in South Africa necessitates exploration into how these companies are being affected by climate change. It is important to investigate what innovations are being undertaken to safeguard their business viability, and what climate change-induced risks and opportunities are anticipated in the future.

This study contributes to the academic debate around innovation for climate change response, by exploring SMEs’ efforts to remain viable through innovation in their products, processes and supply chains (Alam et al., 2022; Crick, Eskander et al.,

2018). The debate further discusses whether self-driven innovation by private entities will be sufficient to overcome the negative effects of climate change, or whether legislative and regulatory measures will ultimately be required in order to enforce compliance with stricter environmental performance standards (Potluri & Phani, 2022; van den Bergh, 2013) developed in accordance with the latest science around climate change.

1.7 Definition of key constructs

Climate change, as defined by the IPCC (2012), is “a change in the state of the climate that can be identified…by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer…due to natural processes or external forcings or persistent anthropogenic changes in the composition of the atmosphere” (p. 557). Stated simply, climate change is alteration in the statistical properties of weather parameters, observed over a long period of time (Princeton et al., 2022).

Responding to climate change involves two interrelated approaches, the first of which entails reducing or avoiding emission of greenhouse gases into the atmosphere, or capturing emissions released previously, i.e. climate change mitigation. The second entails adjusting to the climatic changes already underway due to past and present greenhouse gas emissions, i.e. climate change adaptation. In this study, the term “climate change response” is therefore used to refer to both mitigation and adaptation, as responses integrating both mitigation and adaptation are needed to address the climate challenge (Lee, Yang & Blok, 2020).

Innovation may simply be defined as “the introduction of something new” (Kahn, 2018). It can be new to the context or even to an individual company, not necessarily new to the world, but is generally expected to be value-adding (Granstrand & Holgersson, 2020). Innovation is how an entrepreneur generates new value-creating resources or furnishes existing resources with greater potential for creating value (Drucker, 2002).

A relatively nascent construct linking climate change response with innovation is “climate innovation”. This is defined by Harrison and Mikler (2014, p.2) as “technological innovation to mitigate climate change”. Climate innovation aims to achieve net zero emission of greenhouse gases, which requires both emission

reduction and removal of historical emissions from the atmosphere (Hakovirta et al., 2022). Although these definitions of climate innovation focus on climate change mitigation, innovation is also needed for climate change adaptation (Nyiwul, 2021).

1.8 Outline of research report

The next chapter presents a review of existing literature on innovation and climate change, highlighting the need for more innovation by SMEs to safeguard themselves from adverse impacts of the changing climate, as well as to take advantage of opportunities arising therefrom. As innovation requires investment, literature on investment in climate change response was also reviewed. Chapter 3 outlines the research questions, while Chapter 4 presents the methodology followed to undertake the study. Chapter 5 reports the research findings. In Chapter 6, the research findings are discussed in relation to the literature reviewed in Chapter 2, while Chapter 7 presents the conclusions of the study and recommendations for the industry as well as for future research.

2. Literature review

2.1 Introduction

This chapter presents the debate within academic literature over the relationship between innovation and climate change. It demonstrates the need for this research project as explored through the research questions. Academic literature that describes innovation, climate change, and the linkages between the two concepts was reviewed. Literature about the chosen context for the research project, namely the South African agro-processing industry, was also reviewed. This facilitated understanding of the concepts and the theoretical relationships within the chosen context.

This research project contributes to the debate on the usefulness of *innovation ecosystems* in promoting innovation in response to climate change. This was chosen as an effective theoretical anchor to explore the response to changing climatic conditions by SMEs in the agro-processing industry.

Thus, the literature review commences with a discussion on the current debate over innovation ecosystems. It delves into the concepts and relationships within the context of the focus themes. The conclusion of the literature review will highlight the contribution made by this study.

2.2 Theoretical anchor: Innovation ecosystems

Innovation ecosystems are networks of heterogenous processes and organisations that come together to address a complex challenge, so as to create value for the participants and the end-users of their products and services (Granstrand & Holgersson, 2020). The value derived is realised at the aggregate level, not necessarily at the level of each participating organisation. The aim is to drive continuous improvement rather than find a fixed solution to the challenge, as this is usually an evolving one. There is no end-point to an innovation ecosystem.

Such systems are built around shared resources or knowledge, needed by some or all of the members of the ecosystem in order to grow (Budden & Murray, 2022). Innovation ecosystems are needed when a set of actors wish to establish the infrastructure for collaboration and innovation around a long-term complex problem.

The concept of innovation ecosystems evolved from earlier thinking on business ecosystems, introduced into academic debate in 1993 by James Moore, a thought leader in business strategy (Moore, 1993). A similar concept of 'innovation systems' was in use until the 'eco- 'prefix was added to show that these systems are meant to mimic natural ecosystems, in which the participants are interdependent (Granstrand & Holgersson, 2020).

Actors within an innovation ecosystem collaborate as well as compete, akin to natural ecosystems. According to more recent definitions of the concept, the actions, as well as the artifacts produced, are incorporated into the system (Granstrand & Holgersson, 2020). Figure 1 illustrates the main actors within a multi-stakeholder innovation ecosystem.

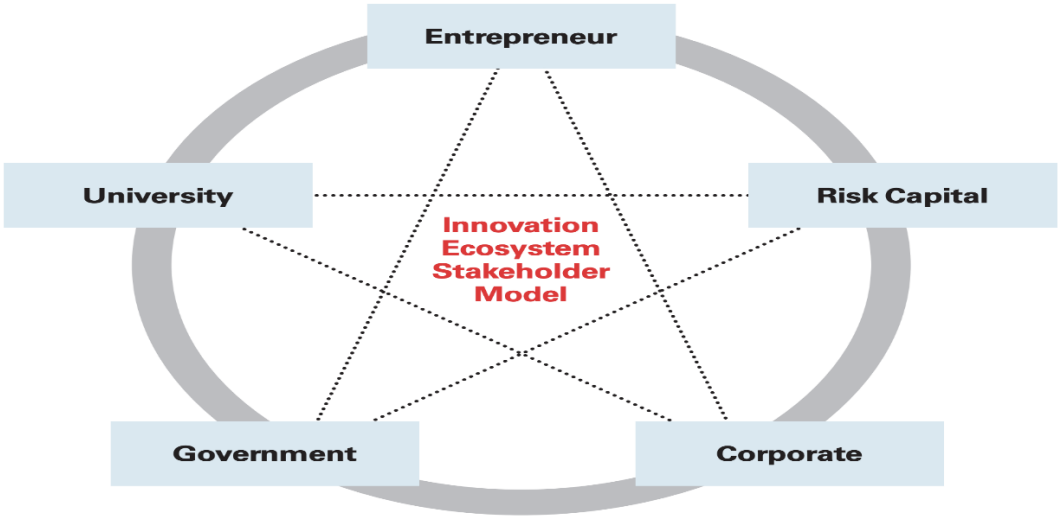

Figure 1: Key stakeholders in an innovation ecosystem (Source: Budden & Murray, 2022)

As shown, the main stakeholders in an innovation ecosystem include entrepreneurs, universities, research institutes, government at various levels (national, provincial and local) as well as governmental agencies, corporates in the industry, and providers of capital (Budden & Marray, 2022). The contribution of the entrepreneurs in the ecosystem is the agility, which enables innovative action. Universities and other research institutes conduct scientific research and provide the latest knowledge needed by other stakeholders. Government and its agencies set the legislative and regulatory framework, provide access to the services needed for the other stakeholders to operate, thus creating an enabling environment for innovation.

Despite being competitors, corporate entities in an industry can have a mutually beneficial symbiotic relationship with their SME counterparts (Hakovirta et al., 2023).

Collaboration enables entrepreneurs to innovate whilst large firms are able to embrace and scale up new trends. Corporate leaders can also mentor and support entrepreneurial operators which helps boost managerial acumen and profitability of SME businesses (Vahedna, 2019). Providers of capital can fund needed research and development, boosting capabilities of innovators to prototype their innovations and implement them (Budden & Murray, 2022).

The need for an innovation ecosystem in the agro-processing sector arises because SMEs in this sector would benefit from the knowledge sharing around potential climate change impacts. This could guide the framing of industry response measures, as well as the research and development that such an ecosystem fosters. Rather than individual firms "reinventing the wheel" in response to climate change, companies can co-develop knowledge and technology that benefits all players (Granstrand & Holgersson, 2020).

Other important stakeholders in the particular context of agro-processors are industry bodies, which foster knowledge sharing specific to the industry. These include farmers' associations, as farmers are the suppliers of inputs to the agro-processors. Additionally, their experience of climate change is more direct, positioning them as an important source of information for agro-processors. Consumer associations are also useful in providing information on evolving customer needs and preferences (Saari et al., 2021).

2.3 Innovation in response to climate change

Innovation can take several different forms, but in this study, three types of innovation are discussed in relation to climate change response. *Product innovation* is product enhancement that improves function or form, such as adding new options or features to an existing product, to provide distinct advantages over the original product (Kahn, 2018). *Process innovation* is a change in a company's production process that enhances efficiency, by facilitating higher throughput, speedier processing, or reduced cost (Kahn, 2018).

Supply chain innovation is a change within a company's supply chain network, or technologies or processes used in the supply chain, undertaken to augment creation of value for the company's stakeholders (Kahn, 2018).

Political, economic, infrastructural and geographical conditions vary considerably across different locations. Consequently, climate change can present opportunities in some locations, whilst being a threat in others (Pinkse & Kolk, 2010). Businesses need to be aware of the variety of ways to safeguard themselves from negative effects of climate change, and/or exploit opportunities arising therefrom. For instance, new products can be created or existing ones modified in response to changing customer demands driven by the changing climate (Durán-Sandoval et al., 2023).

Businesses can also innovate along the operational value chain to increase resource use efficiency, particularly of energy and water. Increasing energy efficiency reduces greenhouse gas emissions, while improving water efficiency reduces the impact of water scarcity for sustainable operations. A business can also innovate along its supply chain, for example, by sourcing raw materials that are produced in an environmentally conscious manner. All these are forms of climate innovation, extending the definition proposed by Harrison and Mikler (2014).

Some researchers argue that climate challenge is more likely to be solved by environmental regulation than by technological innovation (Su & Moaniba, 2017; van den Bergh, 2013), while others see innovation as a critical part of the solution (Alam et al., 2022). For an individual business, the choice to innovate may be essential to the company's survival, especially if it depends on input from climate-sensitive sectors, such as agriculture.

Furthermore, considering that developing a new innovation from conceptualisation to mainstream production often requires changes in technology, regulations, infrastructure and consumer behaviour (Matos et al., 2022), SMEs need an enabling ecosystem, if innovations are to succeed.

In a quantitative study of over 400 SMEs in 14 middle-income countries over a ten-year period, Alam, Du, Rahman, Yazdifar and Abbasi (2022) found that fast-growing SMEs in highly profitable industries had a greater tendency to innovate in response to climate change. The results further demonstrated that SMEs tend to spend more on innovation as a percentage of turnover than larger companies do. The authors concluded their article by recommending that their findings be corroborated through qualitative research and analysis. This study undertakes this challenge by exploring the perspective of South African SMEs.

2.4 Climate change response in the Southern African region

There is abundant scientific evidence that the earth's climate has changed significantly since the dawn of the first industrial revolution (Scholes & Engelbrecht, 2021). The primary cause of this change is the exponential increase in the emission of greenhouse gases, mostly from the use of fossil fuels. The effects of climate change include sea level rise, storm surges, increasing temperatures, changes in the distribution, timing and intensity of rainfall, and increased probability and frequency of extreme weather events (Tall et al., 2021), all of which can affect businesses in climate-sensitive sectors.

In Southern Africa, vulnerability to climate change is higher than average because of the region's geographical location and generally lower state of socioeconomic development. The region is warm and water-scarce, and projected to become even warmer and drier, placing new demands on its resources and institutions. Warming in the interior of the region is twice as fast as the global average rate (Scholes & Engelbrecht, 2021). The region is projected to experience increased drought, with a resulting higher risk of undernutrition (Tall & Brandon, 2019), in a region that already suffers this scourge.

Focusing on South Africa, the maps in Figure 2 below, from the South African Weather Service (SAWS) Climate Change Reference Atlas (2017), show the projected annual total changes in temperature (^{o}C) and rainfall (mm/year) in the period 2036-2065, compared with the period 1976-2005, under a moderate emissions scenario. The x- and y-axes show the longitudes and latitudes.

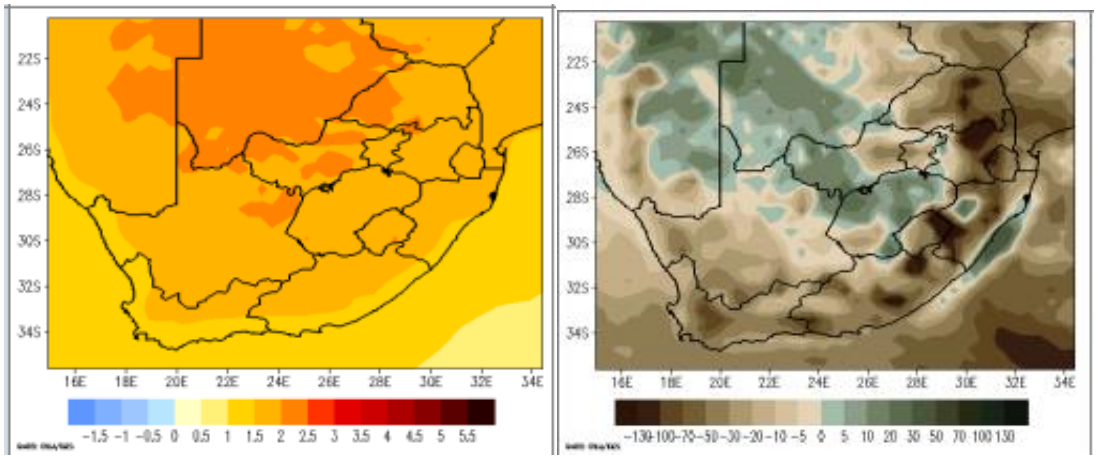

Figure 2: Projected annual total changes in temperature and rainfall in 2036-2065 (Source: SAWS, 2017)

The first map shows that the whole of South Africa is becoming hotter, with parts of the Northern Cape, North-West and Limpopo provinces warming faster than the rest of the country. The second map shows that some parts of the country are becoming drier, while others rainier. Large areas of the Free State, North-West and KwaZulu Natal, and small areas of Limpopo and Mpumalanga provinces are experiencing heavier rainfalls, while the rest of the country receives less precipitation than before (SAWS, 2017).

According to climate scientists, there is a high likelihood of decline in agricultural production in Southern Africa overall, because average temperatures in the region are already higher than the optimum for most crops and livestock. As the region becomes even drier, soil moisture will be less sufficient to support crop and forage production. The region's capacity to compensate for this by increasing irrigation is limited by the declining availability of both surface and groundwater, as well as competing demands from other economic sectors for the limited water that is available (Scholes & Engelbrecht, 2021).

This has diverse implications on food and beverage production. For example, grape production in South Africa for wine-making is already in decline because the periods of cold weather needed for the grapevines to blossom are becoming shorter; the country recorded a 10% decrease in wine grape production in the 2023 harvest season (Thatch, 2023).

On the other hand, some areas that used to be susceptible to frost will become more favourable for fruit production as the climate warms up, but might at the same time become more susceptible to diseases and pests (Scholes & Engelbrecht, 2021). All of these changes necessitate innovation in food systems, to sustain food security in the region.

In South Africa, limited financial and skilled human resources are available at national, provincial and municipal levels to implement initiatives to address climate change (Sibiya et al., 2023). There is also tendency to view climate volatility as an environmental problem, which results in it being deprioritised (Sibiya et al., 2023). Meanwhile, the effects are already impacting businesses and communities, particularly in the water-stressed parts of the country. Businesses that have the capacity to safeguard themselves from the negative impacts ought to be encouraged to do so.

According to the Johannesburg Stock Exchange (JSE), the South African private sector is reported to be making progress towards a low-carbon, climate-resilient economy (JSE, 2022). This is particularly true for companies listed on the JSE, which are required to conduct environmental, social and governance (ESG) reporting and disclose climate risks and effects on operations and viability (JSE, 2022). However, the extent to which smaller companies recognise climate risk and take action to manage it remains unclear.

In the South African manufacturing sector, the Small Enterprise Development Agency (SEDA) defines SMEs are defined as businesses with less than 200 staff, annual turnover of less than 765 million ZAR and gross asset value of less than 15 million ZAR (SEDA, 2023). SEDA estimates that around 2.7 million SMEs are operating in the country, providing about 10 million jobs, approximately 60% of total employment in the country (SEDA, 2023). Thus, the SME sector constitutes a significant part of the South African economy. It is important, therefore, to investigate how these smaller firms allocate resources towards climate change response.

There is a clear business case for private companies of all sizes to invest in climate change response. A survey by the World Economic Forum (WEF) of 100 major global companies found that losses due to physical impact of climate change equate to 10% of annual turnover (WEF, 2022). Over time, climate change can affect business viability if a company takes no action to safeguard itself. Smaller companies have fewer resources to enable adaptation efforts, and are hence likely to face greater impact.

As added complexity, climate change is shifting demand patterns for various goods and services. This is set to enhance opportunity in a range of sectors. Being vigilant about identifying and exploiting these opportunities can yield benefits from the changes in climate. Companies that engage in a response agenda pave way for partnership with government and civil society in shaping the environment of business, thereby improving the operating conditions (WEF, 2022).

However, for individual businesses, it is challenging to determine to what extent their operations are affected by climate change, as the effects are multifaceted (Sautner et al., 2023). Even among companies within the same industry, impacts of climate change are not uniform. Thus, private entities endeavour to manage climate risk in a variety of ways. Some are modifying own supply chain and operations to reduce

vulnerability (Crick, Gannon et al, 2018). Others have partnered with government in infrastructure development to increase climate resilience (Keenan et al, 2019). Sponsoring training of stakeholders on climate change adaptation measures is another intervention. Manufacturing companies may invest in research and development (R&D) to take advantage of business opportunities emanating from climate change. The financial sector has started availing financing for investment into mitigation and adaptation measures.

Smaller companies face more challenges in responding to climate change than larger ones do (Alam et al., 2022), as they lack resources to commit and may also lack the skills required to effectively modify their operations and surroundings. On the positive side, being smaller in size often entails greater agility, as well as more flexibility to innovate in rapid response to external changes (Alam et al, 2022).

As South Africa is the twelfth largest emitter of greenhouse gases globally (JSE, 2022), there has been greater international interest in supporting the country's climate change mitigation rather than adaptation efforts (Winkler et al., 2021). However, recognising that it is a water-scarce country and projected to become even more so due to climate change (Sibiya et al., 2023) magnifies the urgency for local public and private efforts to invest in climate change response programmes that can safeguard public and private assets, as well as communities.

2.5 Innovation and food systems

The actors and activities that form part of the food and beverage supply chain are collectively called food systems (Durán-Sandoval et al., 2023). The interactions between food systems and the climate system may be the main cause of future food insecurity, if businesses in the food and beverage sector are not supported by innovation ecosystems. This is because climate change has the propensity to adversely affect all aspects of food security, namely, food availability, access, utilisation and stability (Durán-Sandoval et al., 2023).

Food systems are major drivers of climate change (Durán-Sandoval et al., 2023). They are the source of high amounts of greenhouse gas emissions through deforestation, land degradation and usage changes, emissions from livestock, the use of fossil fuels in mechanised farming and in the transportation of agricultural produce and finished products as well as emissions from the decomposition of food

waste. It is estimated that over one-third of global greenhouse gas emissions emanate from food systems (Durán-Sandoval et al., 2023).

Conversely, food systems are heavily impacted by climate change (Zurek et al., 2022). Erratic weather patterns affect agricultural productivity and output, causing changes in pest populations and areas of infestation. This affects storage conditions required for raw produce and reduces the shelf life of finished products.

The interactions among the climate system, the food system and natural ecosystems are depicted in Figure 2.

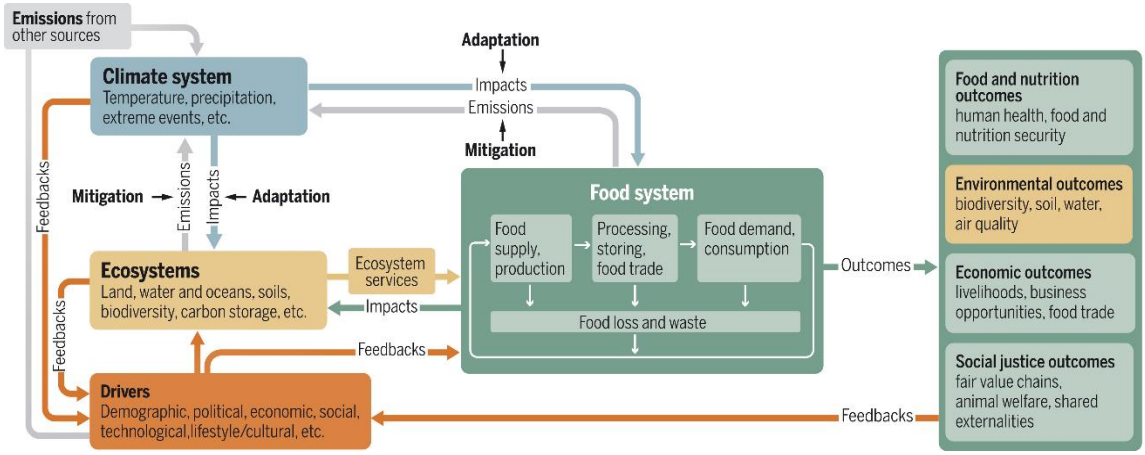

Figure 3: Interactions among the climate system, natural ecosystems and the food system (Source: Zurek et al., 2022)

Examining the climate and food system interactions reveals that climate change response in the processed food and beverage industry requires innovation for both mitigation and adaptation initiatives. Climate change mitigation actions can include reducing food loss and waste through dynamic technologies, increasing energy efficiency, and use of renewable energy in production processes (Zurek et al., 2022).

Adaptation actions by agro-processors could entail changing product ingredients to use inputs more suited to the emerging climatic regime, e.g., drought-resistant crops, in places where the climate is becoming drier (Zurek et al., 2022). Mitigation actions include improving resource use efficiency and converting from non-renewable to renewable resources (Harrison & Mikler, 2014). Resource constraints can be a source of innovation (Fisher, 2012); thus, agro-processors ought to perceive adaptation and mitigation actions as opportunities to innovate. Agro-processors can work with supplier farmers to introduce climate-smart agricultural practices that

maintain food availability in a changing climate (Zilberman et al., 2018). Agro-processors could also relocate to areas with more favourable climate for required inputs, as an adaptive strategy that would have mitigation co-benefits of reducing transportation costs and emissions.

A more holistic strategy for climate change response in food systems is the circular economy approach. This approach applies the principle that material waste from a production process can be used as a valuable input into another. In so doing, resource use efficiency is increased and environmental impacts from raw material extraction and waste management are reduced (Yang et al., 2023).

In food systems, circular economy can be applied to both food and the packaging thereof. In the former, this entails recycling or reuse of waste, whether generated internally or sourced from elsewhere, and reduction in the utilisation of virgin resources (Dlamini, 2022), as well as use of waste to produce by-products that can also be sold (Yang et al., 2023). Use of reusable or recyclable packaging reduces the quantity of raw materials that have to be extracted to produce packaging, thereby saving energy and lowering greenhouse gas emissions (Phelan et al., 2022).

Transforming food systems in line with climate change is a complex challenge, with several different actors and actions required. Dinesh, Hegger, Klerkx, Vervoort, Campbell and Driessen (2021) propose six elements of a theory of change for the transformation of food systems under the changing climate, presented in Figure 4, below.

Figure 4: Theory of change elements for food system transformation under climate change (Source: Dinesh et al., 2021)

Each element of the theory of change has innovative aspects. Evidently, the government has a key role in fostering innovation in food systems, with enabling policies and institutions being at the centre of the theory of change. But the rest of the nodes in the theory of change can be led by private entities. It is neither necessary nor efficient for each entity in the food system to conduct its own research and develop its own technologies and other measures to mitigate and adapt to climate change, as this can be achieved through collaboration among the entities of an innovation ecosystem, while each company develops specific products that it can patent and market, in order to enhance its competitive advantage (Bacon et al., 2020).

2.6 Climate change response in agro-processing SMEs

Although the involvement of SMEs in agro-processing is notable in developing economies, a majority of these businesses operate informally, leading to limited access to financial resources. This limitation hinders their growth, competitiveness, and ability to innovate. Internal challenges, including low entrepreneurial, managerial, and technical capacities, further hinder their development. Additionally, external factors such as inadequate access to electricity, water supply, transportation, and telecommunications, particularly in peri-urban and rural areas, pose obstacles to sustainability. (Crick, Gannon et al., 2018).

The influence of market drivers significantly shapes private investment in climate change response, with companies adjusting to evolving demand for new solutions in response to changing climatic conditions (Crick, Gannon et al., 2018). For example, declining rainfall in an area dependent on hydroelectric power would raise demand for solar power systems. Governments can foster business investment in climate change response by offering economic incentives like subsidies and tax breaks. SMEs have identified opportunities emanating from climate change and are actively innovating to introduce new products and services (Alam et al., 2022). Access to climate information services, as well as early warning systems for adverse weather events, play a crucial role in enabling these businesses to plan and prepare for disruptions in water supply, flooding, or electricity load shedding. (Crick, Gannon et al., 2018).

Conversely, market imperfections may deter private investment in climate change response. Positive externalities, such as benefits resulting from an investment that accrue to entities other than the investor, may discourage private firms from investing in adaptation (Stoll et al., 2021). Imperfect financial markets also have a bearing, as one of the key purposes of financial markets is to correctly price risk and opportunity so as to inform investment decisions (Giglio et al., 2021).

However, the limited disclosure of climate-related risk distorts the financial markets (Tall et al., 2021). Asymmetrical information between SMEs and listed competitor companies can also negatively impact the SMEs. Public firms are more aware of climate risk due to disclosure responsibilities (Sautner et al., 2023). Addressing market imperfections could have a positive effect on SME investment in climate change response. It is anticipated that with time, regulatory requirements or investor expectations will steer SMEs towards measuring and disclosing exposure to climate risk (Giglio et al., 2021), paving way for more investment in climate change response.

SMEs tend to be more flexible and creative than larger companies in adapting their operations in response to climate change, thereby deriving environmental, technological and reputational benefits (Alam et al., 2022). Some practical climate change response measures that SMEs can take are presented in Figure 5, below.

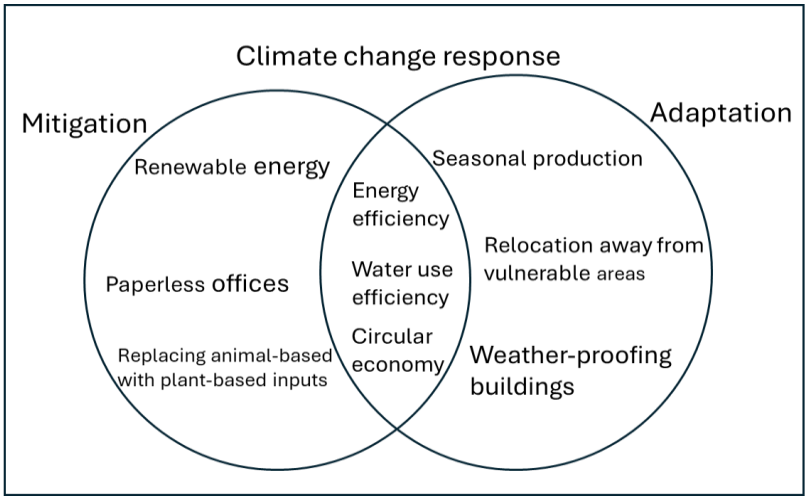

Figure 5: Practical options for climate change response by agro-processing SMEs (Source: Author, adapted from Rabinowitz et al., 2023)

As shown in the figure above, climate change response encapsulates mitigation and adaptation. Mitigation options that agro-processing SMEs can implement include installing renewable energy options such as solar power systems, going paperless,

and substituting plant-based inputs for animal-based ones. Each of these responses reduces the amount of greenhouse gases emitted (Rabinowitz et al., 2023). Adaptation responses include producing seasonally based on availability of inputs rather than maintaining the same product lines year-round, moving facilities away from areas vulnerable to adverse climatic events, or weather-proofing facilities to prevent damage. Interventions that enhance energy and water use efficiency or facilitate circular economy deliver both mitigation and adaptation benefits (Pollo & Trane, 2021).

Climate change presents individuals, businesses and governments with a high level of risk and uncertainty, because climatic models cannot predict exactly what will happen in each locality (Crick, Eskander et al., 2018). Furthermore, as economic activity drives climate change, any uncertainty about economic growth rates exacerbates uncertainty about climate change (Giglio et al., 2021). Thus, determining when to invest in order to avoid a risk or exploit an opportunity arising from climate change can be difficult, especially considering numerous competing priorities and alternative investment opportunities.

2.7 Public versus private sector climate change response

Responding to climate change involves implementing strategies for mitigation and/or adaptation, wherein companies make operational changes or investment decisions to counter climate risks (Crick, Gannon et al., 2018). Despite this, the reluctance to engage in climate change response is attributed to high initial costs and the unpredictability of return flows (Stoll et al., 2021).

The uncertainty surrounding climate risk hampers a comprehensive understanding of its implications, impeding effective responses to either mitigate or adapt (Todaro et al., 2020). The intricacies of assessing climate vulnerability and its associated costs pose challenges in determining the required investment amounts (Keenan et al., 2019). Moreover, financial markets' preference for short-term loan maturity clashes with the long-term debt needs for adaptation investments, due to their high upfront costs and long payback periods (Stoll et al., 2021).

Nonetheless, both the public and private sectors express interest in deriving benefits from adaptation investments, with the key difference lying in how they perceive the benefits. While adaptation investments may be less appealing to private entities

compared to opportunities with immediate revenue potential (Keenan et al., 2019), the lack of information availability or accessibility hinders businesses in many developing countries from making appropriate investments (Stoll et al., 2021).

An additional challenge is the potential for elite capture in private investment for adaptation, where investments primarily align with individual interests rather than benefiting the broader society (Keenan et al., 2019). A focus on self-interest or a lack of experience in climate response may lead private actors to adopt counterproductive adaptation strategies, ultimately increasing vulnerability (Stoll et al., 2021).

Conversely, public sector actors, influenced by political considerations, may prioritise investments with immediate social and economic development impacts. Achieving consensus between private and public actors on what should be prioritised becomes challenging, and the outcomes of investments may not align consistently with the initial intentions of either party (Keenan et al., 2019).

Despite these obstacles, governments acknowledge the risks posed by climate change and actively seek private participation to co-finance adaptation and mitigation projects. Individual companies also contribute to climate finance as part of their corporate social responsibility initiatives. However, these contributions fall significantly short of the required funding volumes. Advocates for private sector involvement in adaptation must convincingly demonstrate to stakeholders that modifying assets and operations for increased resilience aligns with strategic interests. Furthermore, such engagement opens avenues for innovation and seizing opportunities arising from climatic changes (Stoll et al., 2021).

It is reported that some governments in lower-income countries hold the belief that climate change responses should be entirely funded by grants from higher-income countries, rather than relying on local actors. Consequently, they do not make efforts to mobilise local private sector financing (Stoll et al., 2021). Even in countries such as South Africa, where the government actively seeks partnerships with private companies for climate risk management initiatives (Winkler et al., 2021), various barriers impede private investment in climate response. These obstacles include the absence of localised climate information to guide investment decision-making, a lack of clarity on the required amount of private investment, and perceived or actual low return on investment (Tall et al., 2021).

2.8 Current challenges to investment in climate change response

Practitioners in advanced and emerging economies alike recognise the value of climate change mitigation efforts. For instance, electricity from renewable sources, can be sold at a profit. In contrast, adaptation is seen as less profitable and therefore tends to attract less investment (Adhikari & Chalkasra, 2023). Research highlights various challenges encountered in attracting the essential private investment required to progress societal adaptation initiatives, particularly in low-income countries. These obstacles include the lack of localised climate risk and vulnerability data to inform investment decision-making, a lack of clarity regarding where private funding is necessary to bridge public investment gaps, and a projected or actual low return on investment (Tall et al., 2021).

Current literature on private sector climate change response has mostly focused on large companies in high-income countries (Alam et al., 2022; Crick, Gannon et al., 2018). However, businesses of all sizes in all countries are progressively taking action to address climate risk (Sage, 2023). Thus, investors increasingly demand that potential investment recipients disclose climate-related risks to their viability, recognising the strategic significance of climate change impacts on business (Stoll et al., 2021). Insurers are also incorporating climate change-induced risks into their risk assessment criteria, as this encourages the funding of adaptation projects (Keenan et al., 2019). Corporate responses to climate change appear to be influenced by awareness of and exposure to climate-induced risks (Todaro et al., 2020).

Private investment in climate change response in developing countries is not well-researched (Stoll et al., 2021), and neither is the effect of climate risk on private investment decision-making (Giglio et al., 2021). However, existing literature indicates that domestic sources of finance are often sufficient and competitively priced to support local climate change responses, even in lower-income countries. (Keenan et al., 2019). This leads some researchers argue that the primary constraint is the bankability of projects rather than a lack of funds (Stoll et al., 2021). From an insurance point of view, the central issue lies not in the absence of funds but in the scarcity of projects suitable for conventional underwriting (Keenan et al., 2019). Other scholars contend that there are limited financial resources available in emerging economies such as South Africa to fund climate change response

investments (Sibiya et al., 2023). It is likely that this challenge is more dire in lower-income countries.

Compared with mitigation investments, adaptation investments are characterised by longer maturities, higher uncertainty and lower immediate returns (Tall et al, 2021). In lower-income countries, the adoption of sustainable adaptation practices, such as weather index crop insurance, remains relatively low compared to higher-income countries (Crick, Gannon et al., 2018). As a result, private investment in adaptation often relies on public sector initiation, to minimise risk and enhance project viability (Keenan et al., 2019). However, there is insufficient research attention to provide guidance to governments in lower-income countries on how to stimulate and foster domestic private sector investment in adaptation (Crick, Gannon et al., 2018).

Another identified challenge is that the patterns of interaction between international donors and local actors have persisted from development aid into climate change response (Funder & Dupuy, 2022). Some local actors in lower-income countries may not perceive themselves as responsible for funding climate change response, anticipating that such funding should come from the higher-income countries that contributed to climate change. However, current flows of international climate finance from developed to developing countries are insufficient to cover the growing costs of climate change response. Hence, it is crucial to move beyond the 'donors versus recipients' dynamic and consider the divergent interests among countries, as well as among domestic actors. The interests of both private actors and the government must be taken into account, and differences in interests within those groups must be acknowledged (Funder & Dupuy, 2022).

Intent on examining drivers for manufacturing companies to undertake climate change response initiatives, Todaro, Testa, Daddi and Iraldo (2020) surveyed managers in Italy . The study explored the effect of cognisance of climate change, perception of firm level exposure to climate risk, and level of risk tolerance, on the adoption of company responses. The findings indicate that awareness only supports climate response when coupled with experience of climate impacts (Todaro et al, 2020). Furthermore, it emerged that risk tolerance moderates the relationship between managers' perception of climate risk exposure and decision to take responsive action (Todaro et al., 2020).

2.9 Climate change response as risk management

Climate change response can be conceptualised as a form of risk management aimed at preventing loss and damage from adverse climatic conditions and events (Baarsch et al., 2020). Risk management theory posits four techniques for dealing with risk, namely avoidance, transfer, reduction or retention, all of which are applicable to managing climate risk.

Risk avoidance is a strategy that seeks to prevent the likelihood of a risk occurring by not undertaking the activity that would expose the business to threat. For example, a business could choose to stop making a product whose inputs are becoming more scarce under the changing climate, and instead manufacture a product whose inputs are not climate-sensitive.

Risk transfer outsources the risk to a different entity, often through insurance. Some aspects of climate risk can be insured against, while others are regarded as force majeure. Risk mitigation involves taking measures to lower the impact of a risk in case it occurs. A risk retention strategy accepts the likelihood and impact of a risk occurring, and budgets appropriately for it (Bogodistov & Wohlgemuth, 2017).

Climate risk is a function of hazard, exposure and vulnerability (Simpson et al., 2021), as depicted in Figure 5, below. This means that all three factors must be present for climate risk to result in loss or damage. These factors differ from one company to another depending on their activities, resources and locations (Simpson et al., 2021).

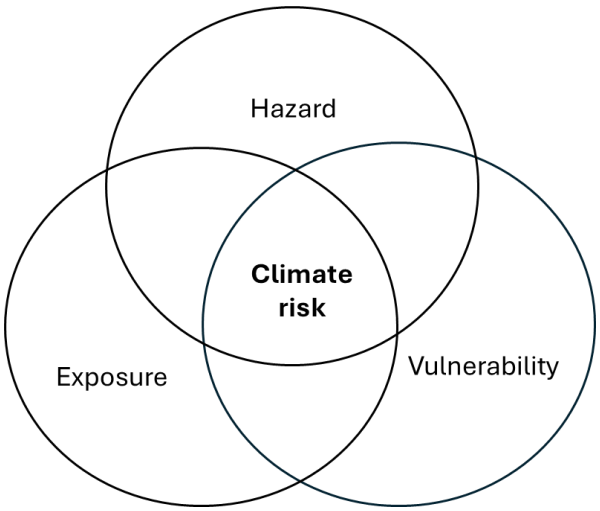

Figure 6: Climate risk as a function of and hazard, exposure and vulnerability (Source: Author, adapted from Simpson et al., 2021)

In the climate change context, hazards are potential occurrences of extreme weather events that could cause loss and damage. Exposure is the presence in a particular location of people or resources that could be adversely affected if the hazard occurred. Vulnerability is the propensity of those people or resources to be adversely affected by hazards. Although climatic hazards cannot be entirely avoided, exposure and vulnerability can be reduced through innovation (Simpson et al, 2021).

A survey undertaken in Kenya and Senegal gathered feedback from 325 SMEs (Crick, Eskander et al., 2018) and found that companies whose operations are affected by climatic hazards are more inclined to invest in climate change response. A business environment in which SMEs have access to finance, markets, relevant climate information and external support makes it easier for companies to manage climate risk (Crick, Eskander et al., 2018).

This study explored the South African SME context and investigated the impact of climate change risk on investment decisions (Crick, Eskander et al., 2018). The study focused on physical climate risk, i.e. risks related to the physical impacts of climatic changes and extremes, rather than transition risks, which are societal and financial risks related to the transition to a less carbon-intensive economy (Giglio et al., 2021).

The operational resilience of agro-processing SMEs is important to research, because current and future food security depends on it. Operational resilience is the capacity of a business to avoid disruptions to their operations, as well as to respond rapidly and recover from disruptions if they do occur (Stolker et al., 2008). To minimise disruptions to food availability, it is important to safeguard the operational integrity of agro-processing SMEs. Improved understanding of what support these SMEs need was one of the intended outcomes of this study.

2.10 Conclusion of the literature review

Innovation ecosystems are proposed as a mechanism to foster agro-processing SME innovation in response to climate change. Agro-processors can introduce innovations through products, processes and supply chains (Kahn, 2018), so as to minimise climate-induced risks and take advantage of climate-induced opportunities.

Food systems are both a driver and a victim of climate change, hence the need for innovation in the food industry, for both climate change mitigation and adaptation

purposes (Zurek et al., 2022). Southern Africa is a region particularly vulnerable to climate change (Scholes & Engelbrecht, 2021); thus, innovation will be necessary to sustain food security (Durán-Sandoval et al., 2023).

Market drivers have a strong influence on SMEs' ability to invest resources in responding appropriately to climate-induced risk and opportunity. It is critical that all levels of the private sector – large, medium and small companies – invest in climate change response, for continued viability and growth.

A longitudinal, quantitative study of SMEs across 14 developing countries found fast-growing SMEs in highly profitable sectors invest more resources towards innovation, in response to climate change (Alam et al., 2023). This study corroborates these finding through qualitative study of SMEs in South Africa's agro-processing industry, specifically food and beverage producers, with the aim of determining what will be needed to sustain them under an uncertain climate future.

This chapter concludes with a tabulated summary of the key findings of the study's anchor papers, as well as the research gaps therein that this study aimed to contribute towards filling. This summary is presented in Table 1, below.

Table 1: Key findings and research gaps of the study's anchor papers

Citation	**Title of article**	**Key finding**	**Research gap**
Alam et al., 2022	"SMEs respond to climate change: Evidence from developing countries"	Climate change has a notably positive influence on the innovation performance of SMEs, especially in rapidly expanding enterprises with ample slack resources.	The study was quantitative; thus, its findings were limited to the multi-choice options provided in the questionnaire. The findings required corroboration and extension through qualitative research.
Crick, Eskander et al., 2018	"How do African SMEs respond to climate risks? Evidence from Kenya and Senegal"	Financial obstacles are a primary factor leading companies to adopt unsustainable climate response measures. Conversely, businesses are prompted to pursue sustainable responses	The study highlights to need for further investigation of the influence of climate risk on SMEs' investment decisions, as well as how climate risk filters

		when they receive financial support, gain better access to information technology, and receive technical guidance in their response efforts.	through the value chain.
Durán-Sandoval et al., 2023	"Food, Climate Change, and the Challenge of Innovation"	To counteract the negative effects of climate change on food security through innovation, it is essential to intervene in the design of enabling institutions, engage in philanthropy, establish strategic partnerships, enhance financial mechanisms, and foster international cooperation.	Further analysis of the roles of institutions, financial service providers, international development organisations, and government in driving innovation in food systems is needed.
Granstrand & Holgersson, 2020	"Innovation ecosystems: A conceptual review and a new definition"	Innovation ecosystems encompass not just the participating actors but also their actions and the artifacts (products and services) they generate. The effectiveness of innovation by a specific actor or the collective group of actors relies on the enabling institutions and the relationships among them.	The applicability of this concept in a developing country context ought to be assessed, as all the literature cited in this review paper were from developed countries.
Hakovirta et al., 2023	"Corporate net zero strategy-Opportunities in start-up driven climate innovation"	The global, informal innovation ecosystem heavily depends on multinational corporations, academia and research institutions. Nevertheless, SMEs can play a significant role in expediting progress in climate innovation.	The paper discusses the global innovation ecosystem in a generic, loosely defined sense, rather than specific innovation ecosystems expressly established to address a particular challenge.

3. Research Questions

As discussed in the preceding literature review, SMEs in developing countries face challenges in adapting to climate change, as they may lack the resources and skills that larger companies possess (Crick, Eskander et al., 2018). Nonetheless, literature indicates that SMEs tend to be innovative in response to climate change. A quantitative study of 443 SMEs in 14 middle-income countries, found that climate change has a statistically significant positive impact on innovation performance in SMEs (Alam et al., 2022). The authors recommended that the findings be corroborated through qualitative analysis. Thus, this study intended to answer the following overarching research question:

What enabling environment is needed for agro-processing SMEs to innovate more in response to climate change?

To answer this question, this study explores how climate change is affecting SMEs in South Africa, and what actions the SMEs are taking in response to it. The study focuses on food and beverage manufacturing SMEs, as these companies are operating in a climate-sensitive industry and produce to meet basic human needs. Four subsidiary research questions were formulated, to garner information that would contribute towards answering the overarching research question.

The first research sub-question explores how climate change is currently affecting agro-processing SMEs in South Africa.

Research sub-question 1: What climate impacts are agro-processing SMEs in South Africa experiencing?

As food and beverages are fundamental human requirements, it is important to monitor how climate change is affecting the production thereof. It can be expected that the effects of climate change on the production of food and beverages will be exacerbated as climate change intensifies. Thus, there is need to understand how these effects can be managed through adaptive and innovative action. Innovation as a means to foster climate change response is a key theme of the innovation and

climate change literature (Matos et al., 2022) and is explored here in the South African agro-processing SME industry context.

Furthermore, food and beverage production is dependent on raw materials from the agricultural sector, which is directly affected by climate change. This means that some raw materials could become scarcer and more expensive as the climate changes (Durán-Sandoval et al., 2023). It is important to understand food and beverage manufacturers' readiness to modify products, processes and supply chain competencies in line with input material availability patterns. This is necessary in order to secure viability under changing climatic conditions. Understanding the capacity of food and beverage manufacturing SMEs to innovate is critical for forecasting food security as the climate changes. Thus, the second research sub-question explores innovation in this industry in response to climate change.

Research sub-question 2: How are agro-processing SMEs innovating in response to the changing climate?

Alam et al. (2022) found that fast-growing SMEs with higher earnings and more slack resources are more innovative than others in response to climate change. In the present study, this finding was examined qualitatively by asking business owners to describe the innovative interventions being implemented. Matos et al. (2022) report that most research on the relationship between climate change and innovation to date has been conducted in regions in the northern hemisphere. This study contributes to understanding the impact within the southern region of the world, recognised to be more vulnerable to climate change.

Food and beverage consumption patterns may also be affected by climate change, or by increased public awareness of food systems' causative role in it (Saari et al., 2021). Thus, it is imperative for agro-processing SMEs to track these trends and adjust product lines, production processes and value chains in tandem with changing demand patterns.

Fortunately, food and beverage manufacturers have a broad range of options to adapt to climate change. It is of interest to explore what options these companies are pursuing, and whether any of these are innovative, in terms of being new to the industry or location. Innovation is critical in the agro-processing industry, as it will not

be possible to continue manufacturing increasing amounts of demanded products as the climate becomes more unfavourable for cultivation of required inputs.

Looking into the future, it is also important to understand what risks agro-processing SMEs foresee in relation to the changing climate. An excess of risk factors might force entrepreneurs to venture into other types of businesses, which would pose a risk to food security. Thus, the third research sub-question seeks to explore concerns that agro-processing SMEs have over climate change and how it is likely to affect the future viability of food manufacturing.

Research sub-question 3: What risks arising from climate change do agro-processing SMEs identify?

There is a tendency to focus on negative impacts of climate change, however, there can also be benefits for businesses in certain locations, or a shift in consumer preferences for certain foods and beverages. For example, the growing trend in veganism among climate-conscious consumers creates demand for vegan products, which creates opportunities for SMEs to target this growing niche market (Saari et al., 2021). Thus, the fourth research sub-question explores opportunities arising from climate change.

Research sub-question 4: What opportunities arising from climate change do agro-processing SMEs identify?

If entrepreneurs perceive the changing climate as presenting opportunities for commercial activity, they are more likely to stay in the agro-processing industry and be open to diversifying products to meet consumers' evolving needs under the changing climatic conditions.

If SMEs' current experiences and responses, as well as perceived future risks and opportunities emanating from climate change are understood, then it is possible to determine what kind of enabling environment is required in order for them to survive and thrive in spite of the changing climate. This is critically important in order to safeguard food security in South Africa as well as in the broader Southern African region.

4. Research Methodology

As the effects of climate change on business become increasingly apparent, it is essential for companies to innovate in response. The literature review chapter describes the concept of climate change innovation as articulated through a small but growing body scholarly research on the topic.

This study contributes explores the relationship between innovation and climate change, by examining how small companies in food and beverage manufacturing are navigating the challenges posed by climate change. The study foregrounds sustainability concerns in emerging market contexts by capturing qualitative data from food and beverage manufacturing SMEs in South Africa.

This chapter discusses the research design that was employed to capture primary data insights required to answer the research questions. An underpinning philosophy is outlined along with the related implications on the character of the research design and methodological choices.

4.1 Philosophy

The research was guided by interpretivist philosophy, the aim of which is to decipher human interpretations of the social phenomena (Rehman & Alharti, 2016). This is based on ontological belief in the existence of multiple socially constructed realities, rather than a single, objectively measurable one (Rehman & Alharti, 2016).

This philosophy is applicable to the constructs of climate change and innovation, which cannot be objectively quantified. It further entails an epistemological approach that requires the researcher to engage with the subjects and try to understand the phenomena from varied viewpoints (Rehman & Alharti, 2016). Food and beverage manufacturing SMEs in South Africa were of interest because these businesses operate in an emerging market setting and experience challenges in input availability. Climate change is one of the drivers prompting small businesses to innovate.

The research aimed to extend theory through interpretation of the data collected (Cresswell & Cresswell, 2018). The researcher recognised that each context has its own peculiarities in terms of how the local climate is changing and the resources available for small businesses to innovate in response.

4.2 Strategy

This was an exploratory study and qualitative in nature. Saunders and Lewis (2018) conceptualise such enquiry as seeking new insights and supplementing what is known about a topic that remains under-researched. The research explored the lived experience of formulating innovative avenues for addressing climate change-affected aspects of food and beverage production. Specifically, the study examined how South African food and beverage manufacturers are addressing these challenges.

An inductive approach was followed, in which in-depth interviews were conducted with a small number of respondents, to elicit narratives and perceptions that add nuance to the phenomenon under study (Muhaise et al., 2020). This approach was useful in the quest to determine the extent to which manufacturers in emerging market contexts are engaging with the scope of climate change considerations as outlined in literature.

This research corroborates theoretical findings from the literature review with empirical findings from primary qualitative data collected. In doing so, primary data was analysed to determine responses to the research questions.

4.3 Methods

The research was a cross-sectional study capturing respondents' perspectives at a single point in time. This approach is adequate when a study intends to capture insight into practitioner perspectives on lived encounters with a phenomenon (Cresswell & Cresswell, 2018), in this case, climate change.

This research provides a snapshot of the studied phenomenon at the time of undertaking the study (Saunders & Lewis, 2018). It allows for the investigation of multiple research questions at one point in time. The limited time period available for the MBA mini-dissertation makes this the most pragmatic choice of time horizon.

The researcher collected primary data by conducting semi-structured interviews. This method is suited to qualitative research that is exploratory in nature, as it allows the researcher to explore nuances with each interviewee. The semi-structured interview guide comprised simple, open-ended questions that enabled participants to express their views in an unconstrained manner.

The researcher also intended to conduct three expert interviews, so as to triangulate the findings from them with the semi-structured interviews and the literature review. The researcher identified three institutions where experts on agro-processing were likely to be found, and approached them to request interviews. However, no positive responses were received.

4.4 Population

The population of the study was South African-based small- and micro-enterprises in the food and beverage manufacturing industry. This is a subset of the agro-processing industry (Chitonge, 2021) and of the small to medium-sized (SMEs) community of companies as per the classification outlined in the National Small Business Act of 1996, as shown in Table 2. Small and micro-enterprises were selected for this study because, unlike large and medium-sized companies, they are unlikely to have significant resources to invest in interrogating and responding to climate risk, but still need to do so in order to remain viable.

It is understood that the small enterprise manufacturing industry is not homogenous and that the annual turnover and asset values vary widely. It is also recognised that the upper bands of asset value are outdated, as they were set in 1996 and have not been revised since then. However, this remains the official gazetted classification of smaller businesses in South Africa, and was therefore applied to the selection of companies for this study. SEDA publishes revised upper bands of annual turnover for each category, as updated annually through the statistics monitoring agency (SEDA, 2023).

Table 2: Official classification of manufacturing SMEs in South Africa

Sector or subsector in accordance with the Standard Industrial Classification	Size or class	Total full-time equivalent of paid employees Less than:	Total annual turnover Less than: (million ZAR)	Total gross asset value Less than: (million ZAR)
Manufacturing	Medium	200	765	15.00
	Small	50	195	3.75
	Very small	20	75	1.50
	Micro	5	2	0.50

Sources: National Small Business Act, No. 102 of 1996 and SEDA SMME Quarterly Update, 3rd Quarter 2022

4.5 Unit of analysis

The study's unit of analysis was owners of micro, very small and small-sized food manufacturing SMEs in South Africa. These were individuals whose leadership roles included accountability for sustainability initiatives in the company. The responsibilities articulated during the initial screening process determined who was best suited to answer questions about climate change adaptation and innovation initiatives.

4.6 Sampling method and sample size

The sample consisted of owner-managers of 15 small- and micro-sized food and beverage manufacturing SMEs in South Africa that reported having implemented innovations in response to climate change. Inquiry with SEDA and the Food and Beverage Manufacturing Sector Education and Training Authority (FoodBev SETA) resulted in an initial list of companies to reach out to. Screening interactions with each potential participating company were undertaken to confirm suitability to engage with the subject matter at hand. This was done telephonically. An informed consent letter was then sent to the confirmed interviewee for signature.

The final sample size of 15 was considered sufficient because data saturation was tracked and reached when further interviews did not yield any new insights. It is reported from a review of several studies that a phenomenological study such as this one tends to have up to 10 respondents (Cresswell & Cresswell, 2018); so by aiming for 12 respondents as a minimum, the researcher ensured that the findings would be considered valid.

4.7 Measurement Instrument

The measurement instrument was a semi-structured interview guide, presented in Appendix A. It was designed to elicit information that would enable the researcher to answer the research questions. Prompts were used to remind the researcher to ask follow-up questions so as to elicit further information from the interviewee, if the initial response to a question was unclear or incomplete. Consistent with a phenomenological approach, the interview questions made no reference to literature or theory (Cresswell & Cresswell, 2018). Rather, the questions were phrased in terms

that would be familiar to business practitioners, as these were the target respondents.

The discussion guide contained six questions. The first question gathered general information about the company. The next three questions explored perceptions of how climate change is affecting the company, either positively or negatively, or both. The last three questions explored what the company is doing to safeguard itself against negative impacts of climate change, or to take advantage of opportunities arising therefrom, though innovative initiatives. Five of the questions had prompts to remind the interviewer of particular follow-up questions to ask.

As recommended by Jacob and Furgerson (2012), the semi-structured interview protocol was pilot-tested to ensure that it was understandable, elicited the desired information, and could be completed within one hour or less. The tool was further refined after pilot-testing.

4.8 Data collection

Interviewing was used as the primary mode of engagement for data collection. Consistent with a cross-sectional study, qualitative data was collected from each respondent only once, and all respondents were interviewed within a short period of time (Saunders & Lewis, 2018), approximately six weeks, from late November 2023 to early January 2024.

As the interview protocol used to guide each discussion was semi-structured, probing was employed to ask follow-up questions that served to provide further clarity or detail. It was anticipated that each interview would last for a duration of approximately 30 minutes to one hour, consistent with the guidance in literature to keep interviews to less than 90 minutes (Jacob & Furgerson, 2012). The average duration of the interviews was 26 minutes.

Each interview was recorded, so that the researcher could focus on listening to the respondent rather than trying to write down everything that was said. Recording also enabled transcription and coding of the responses. Recordings and transcriptions of the interviews were securely stored on two computers and two external storage devices and will be kept for ten years after the research report submission deadline.

4.9 Analysis approach

The findings from the semi-structured interviews were consolidated through coding and thematic analysis. Consistent with the inductive approach, themes were derived from the data collected (Kiger and Varpio, 2020). Emerging themes are presented in the discussion section of the research report. In Chapter 6, the findings are compared with the literature to identify any consistencies and inconsistencies with the findings of other researchers. From this analysis and comparison, this research project's contribution to the literature is outlined in Chapter 7.

4.10 Quality controls

A consistency matrix was prepared to ensure alignment among the literature review, the research questions and the semi-structures interview guide. This is presented in Appendix B.

To guarantee meaningful outcomes from the measurement instrument, a pilot test was conducted before its actual use with the interviewees. Subsequent revisions were made to enhance the interview flow and facilitate better comprehension of the questions.

The researcher conducted all the interviews in a similar manner, being through online interviews using the Zoom application. The researcher posed the questions in the same order and endeavoured to ask similar follow-up questions, so as to ensure that the data would be amenable to coding and thematic analysis. These measures were undertaken in order to standardise the research situation (Flick, 2018).

Following the interviews, the gathered data underwent validation to verify the measurement instrument's accuracy in aligning with the research objectives. Additionally, reliability checks were performed to ensure that the data had been collected consistently across all interviewees, as recommended by Saunders and Lewis (2018).

The researcher endeavoured to avoid ambiguity in reporting the findings, by using consistent terminology, with definitions of key terms provided (McCracken, 1988). Findings were aggregated across the interviews, so that a consistent set of findings could be reported.

4.11 Limitations

The primary limitation of this study was that as a mono-method study, it did not facilitate validation of the findings through other research methods. Also, investments in climate-responsive innovation may not be easily comparable across the different companies interviewed, because of the challenges the interviewees faced in recognising and reporting them distinctly from other improvements in resource-use efficiency (Keenan et al., 2019).

Furthermore, the generalisability of the findings is limited by the small sample size and the restricted geographical scope of the study. Further, this may affect the external validity of the findings (Saunders & Lewis, 2018), especially as they relate to a phenomenon such as climate change, whose impacts vary in different locations.

4.12 Ethical considerations

The researcher endeavoured to ensure that potential respondents understand the research and fully consented to participating in it. As recommended by Flick (2018), each interviewee was given prior knowledge of the purpose of the research and the opportunity to refuse to take part. The participants were asked to read, sign and return the informed consent letters before being interviewed. The informed consent letter explained the purpose of the research and target contribution. Confidentiality provisions were also stated in the informed consent letter, presented in Appendix C.

Before starting each interview, the researcher reminded the respondents that their identity and responses would be kept confidential, to ensure that no information provided would be used against them. Any potentially sensitive information given by respondents was not reported. The research findings are presented in an aggregate manner. It was envisaged that these assurances would allow the interviewees to be candid in their responses (McCracken, 1988), without concern about any possible repercussions.

4.13 Timeline of research project

Ethical clearance was granted on 25 October 2023. As soon as this was received, the researcher sent meeting requests to potential interviewees that had been identified through the request to SEDA. Once a respondent replied, the researcher

made contact to explain the purpose of the research and convey the informed consent letter. When participation was confirmed by an interviewee, the researcher proceeded to schedule the interview. Data collection commenced in late November 2023 and was completed in early January 2024. Data analysis was undertaken in January 2024, with the findings, analysis, conclusions and recommendations consolidated in February 2024.

5. Research findings

5.1 Introduction

This chapter begins with a summary of the data collection exercise, describing the interviewees and the process followed in identifying them and eliciting their responses. A brief recap of the data analysis process is provided. Then, the findings from the interviews and the analysis thereof are presented.

5.2 Participant identification

Having selected owners of agro-processing SMEs as the target set of interviewees, the researcher approached SEDA and the FoodBevSETA for introduction to potential interviewees. The respondent from SEDA linked the researcher to 15 potential interviewees. The researcher reached out to each of them repeatedly but only three agreed to be interviewed.

One of the three interviewees invited the researcher to the Manufacturing Indaba held in Johannesburg in October 2023, where the researcher met a further 11 potential interviewees. The researcher followed up repeatedly with each of them. Eventually, eight interviews from this group were completed.

A participant from this group invited the researcher to the Young Farmers Summit held in Pretoria in November 2023, where the researcher met a further four potential interviewees. All four interviews were completed. Thus, out of a total of 30 potential interviewees that the researcher identified and pursued, 15 interviews were completed, a response rate of 50%. All the interviews were conducted remotely, using the Zoom online meeting app. Interviews were conducted over a six-week period, from late November 2023 to early January 2024.

5.3 Participant profiles

All 15 interviewees were founders and owner-managers of agro-processing SMEs. Eight owned farms and grew some of the base inputs for the products processed at these farms. This was complemented by sourcing additional inputs from other farmers. One interviewee characterised their business as an agricultural enterprise rather than an agro-processing one, but was included because the company's farms

include sorting and packaging facilities, which are categorised as agro-processing activities.

Seven of the interviewees did not own farms and therefore sourced all inputs from a network of supplier farmers. 14 out of the 15 respondents were female. This was driven by the profile of initial potential respondents from SEDA who were all female. The interviewees' operations were all located in South Africa, across all provinces except the Western Cape and the Northern Cape. However, these provinces were still mentioned in the interviews, as some of the interviewees source inputs from those provinces.

All the entrepreneurs interviewed were within the micro, very small, and small company categorisations, as detailed in the National Small Business Act, No. 102 of 1996. All the participants' companies manufactured packaged food and beverage products ready for consumption, using raw agricultural produce as inputs. The products include condiments, gourmet confectionery, wines, nut butters, herbal teas, flavoured honeys, coffee alternatives and porridges. One-third of the interviewees described their businesses as fast-growing, while the others were growing slowly. Table 3 lists the labels assigned to the interviewees, as well as their product ranges and locations.

Table 3: List of interviewees

Participant label	Company product range	Company location	Province
A1	Wines	Johannesburg	Gauteng
A2	Coffee alternatives	Bloemfontein	Free State
A3	Porridges	Johannesburg	Gauteng
A4	Fruit juices	Pretoria	Gauteng
A5	Pickles	Centurion	Gauteng
A6	Herbs and spices	Pretoria	Gauteng
A7	Nut butters	Gqeberha	Eastern Cape
A8	Egg products	Balfour	Mpumalanga
A9	Indigenous teas	Marblehall	Limpopo
A10	Atchars	Nzhelele	Limpopo
A11	Gourmet confectionery	Durban	KwaZulu-Natal
A12	Wines	Johannesburg	Gauteng

A13	Sauces	Modderfontein	Gauteng
A14	Superfood products	Bosplaas	North-West
A15	Flavoured honeys	Pretoria	Gauteng

5.4 Interview coding and thematic analysis

The 15 interview recordings were transcribed using the Rev AI online app. The transcripts were then uploaded to the qualitative analysis software, Atlas.ti. The researcher coded the transcripts manually. This process yielded 388 quotations and 122 open codes. Saturation was reached at the 11th interview, beyond which no new codes were assigned.

The researcher analysed the 122 open codes and compiled related ones into 27 axial codes. These were then further analysed and compiled into seven themes that respond to the research questions. The full set of themes, axial codes and open codes is presented in Appendix D.

In the subsequent sections, the findings are presented in relation to each of the four research sub-questions.

5.5 Findings related to sub-question 1

The first research sub-question was, 'What climate change impacts are agro-processing SMEs experiencing?" This was explored with the interviewees by asking them to tell the researcher about business operations and the impact of climate change. Table 4 presents the resulting axial codes and theme.

Table 4: Axial codes and theme relating to sub-question 1

Research sub-question 1	**Axial codes**	**Theme**
What climate change impacts are agro-processing SMEs experiencing?	difficulty sourcing inputs, declining quality, cost escalation, unpredictable weather, regional variations, secondary concern	Input reliability challenges

5.5.1 Input reliability challenges

Several of the interviewees explained how climate change was already causing difficulty in sourcing inputs of the desired quantity and quality. The increase in weather unpredictability due to climate change posed a challenge to some interviewees, impacting on production cycles and overall business stability. The struggle to secure essential ingredients is negatively affecting some operations. In response to the interview question about climate change effects on business, interviewee A2 responded:

"E*xtreme weather events are affecting agriculture and disrupting the supply chain for our key ingredients*."

Such supply chain disruptions cause inefficiencies in production, and hamper ability to meet market demand for products. Interviewee A13 had the following to say about difficulties in sourcing inputs:

"*I have to now increase or widen my circle of farmers that I use. And that is what I'm currently doing. So if the one has got a problem, you know, then I have to try and source fresh ingredients from some of the others*."

Interviewees reported that extreme variations in weather are becoming more frequent due to climate change. This has reportedly led to a decline in input quality, affecting the overall quality of processed products. Interviewee A6, who farms the inputs for her products, reported the following about the impact of climate change:

"…*it affects the quality also of plants, you know, the damage the sun does, or this haphazard weather…like now it's cold, and then maybe around two o'clock it'll be very, very sunny. I mean, our plants cannot survive like that. It's risky already because it affects the quality and the quantity*."

SMEs reported dealing with escalation of input prices due to increased demand for the declining quantity of agricultural produce on the market. This instigates overall increases in operational costs, impacting viability and competitiveness. Speaking about the availability and cost of the main ingredient for her products, interviewee A7 said the following:

"…when things are in shortage, like now, it means everything becomes so expensive. Like if I was relying on one supplier, like the one local supplier who is in Cape Town now, they actually don't have it. And we just asked some who are still having it in

Cape Town, they say it's R69 per kilo [November 2023]. The last time in July, I bought it for R50 per kilo. So, because of the shortages, things just quickly go up and it's not nice. This climate change makes everything more expensive, that scarcity. So it's not nice."

Disparities in climatic conditions across the different regions of South Africa contribute to varied challenges. There were notable regional variations in the impact of climate change on input availability, with companies sourcing inputs from Limpopo and Mpumalanga faring better than those sourcing inputs from other parts of South Africa. Several interviewees mentioned sourcing inputs from other regions when supply from own provinces is insufficient. For instance, interviewee A13 said:

I work with organic farmers in Gauteng, and they're fairly small farmers. They've got like eight hectares of land each, and they would then supply me. So for instance, if we can't get enough in Gauteng, then I would go to the farmers in Limpopo."

Interviewee A10 is also sourcing input from a different province:

'In Mpumalanga there's a lot of [fruit] and I know that the climate is almost the same as this side, however, I think that side is better than this side."

5.5.2 Climate change as a secondary concern

Not all interviewees reported current impacts of climate change on operational activity. Some regarded it as a secondary concern, compared with other more pressing issues affecting businesses in South Africa. Interviewee A11 put it this way:

"…*it's hard to pinpoint exactly that it would be specifically climate change because there's a lot of, I think from a political aspect, there's a lot of problems, globally. We had unrest here a couple of years ago. There were floods prior to that. There was a pandemic. And then obviously in the backdrops, the climate change is happening that, you know, catalyses everything and makes it a lot worse at the same time. But climate change in its individual capacity…I can't imagine where someone would actually pinpoint it and say, this is exactly due to climate change*."

Interviewee A12 expressed a similar view:

> "…*climate change, it's something that's happening now. Just like the question you asked about the trees and how's it being affected. Nothing's happened*

so far, right? Remember? So we are not even focusing on what would we have to change in our supply chains, what would we have to change in our production inputs, et cetera, you know, in the event that happened."

It is clear from the different interviewees' experiences that climate change impacts are experienced differently, perhaps depending on whether an agro-processing SME farms its own inputs or not, as well as where it sources its inputs from. There is also an understandable difficulty in distinguishing between climate change impacts and those stemming from concurrent problems in South Africa, such as the electricity crisis and the after-effects of the COVID-19 pandemic.

5.6 Findings related to sub-question 2

The second research sub-question explored how agro-processing SMEs are innovating in response to climate change. The interviewees were asked describe product or process changes already made, or considered in order to remain viable under the changing climate. Table 5 presents the resulting axial codes and themes.

Table 5: Axial codes and themes relating to sub-question 2

Research sub-question 2	**Axial codes**	**Theme**
How are agro-processing SMEs innovating in response to the changing climate?	research & development, product innovation, sustainable packaging	Sustainable production
	alternative farming methods, appropriate technology, climate change mitigation, value chain integration	Value chain management

5.6.1 Sustainable production

The findings show that agro-processing SMEs are innovating in response to climate change by adopting more sustainable business models, that not only manage risks associated with climate change, but also contribute positively to social and

environmental sustainability. For example, instead of aiming to produce consistent quantities of each product, some SMEs have resorted to making products according to what inputs are readily available from farmers. Interviewee A13 explained:

> "…*so the core of the business is sustainability, it's ethical producing of products, and it's also around agro-processing. We work very closely with a few organic farmers, and quite often when they have surplus of ingredients, I mean, if they have surplus of crops, they will give me a call and tell me, you know what? We've got like a hundred kilograms of [fruit]. Can you please take it off our hands? So instead of the produce getting rotten, and that is a huge problem when it comes to farmers, is that their products aren't being processed…so I would take that fresh ingredient, I would process it to create a product*."

Interviewee A9 described product innovations that are already underway in her company, that involve repurposing the waste generated from production of the company's main products:

> *"We are looking at ways to contribute positively to the environment through our production and processing. To really ensure that we are reducing our impact, negative impact to the environment, reducing our carbon emissions, our wastage…actually producing other products from our wastage, that's also why we are diversifying as well....we are using our wastage to make our [alcohol product], for instance. We are looking to create skincare products as well, or animal feed out of our wastage."*

This approach to the management of waste from agro-processing helps to mitigate against climate change, because the decrease in the amount of agricultural waste sent to landfill lessens the quantity of harmful gases emitted into the environment, thereby reducing the greenhouse effect that causes climate change.

Some interviewees reported looking beyond local markets to source sufficient quantities of inputs, of the desired quality. Interviewee A3 highlighted intentions to source additional inputs internationally:

> "*So at the moment, our main suppliers are within the northern region, which is the Limpopo and Mpumalanga region. Those type of regions tend to be a little bit more dry throughout the year, and they tend to sustain higher temperatures as well…we've tried to branch out into our neighbouring*

countries such as Botswana. Uganda also has very good production, very rich, throughout the entire year."

Interviewee A3 described similar intentions, but to expand the business internationally rather than import inputs:

"*We are also going to be branching out in maybe Zambia. Even in Zambia, they have the same problem of, of waste, of food waste. Like, they've got a lot of [fruit] which are, are being put to waste. So instead of us having to go and source from that side and bring them this side, we might as well just open a factory that side. Then hire people from that side. Then, we teach them the process of how you do it and everything*."

5.6.2 Value chain management

Several interviewees reported attempts at vertical integration of their value chains, in response to climate change. The interviewees whose companies farm their own inputs reported exploring alternative farming methods that would help ensure a continuous source of inputs under a changing climate. Farming in greenhouses seems to be of particular interest. The interviewees who do not farm own inputs are looking into sourcing from farmers that have greenhouses, so as to secure quality and quantity of inputs. Attributing this to climate change, interviewee A15 said:

> *"Others are reverting to farming in greenhouses. We are seeing that a lot now in South Africa. Why? Because um, people are afraid to farm open land because of the changes that are happening with the climate."*

Interviewee A6 explained how she has had to resort to supplement her produce by buying inputs from farmers who have greenhouses:

> *"I used to plant [herbs] and in winter they would grow very fast. But this time because of the frost, my plants are not doing that well…hence, I've got a challenge with some of my things. Then I go to another farmer, you know, those ones that they have greenhouses."*

Additionally, agro-processing SMEs who farm inputs are already investing in early warning technologies to forewarn them of unfavourable conditions, so as to prevent losses. Interviewee A2 explains:

“We are working on a system where we can foresee climate conditions coming that may affect the [vegetables]. So we already ahead of time. We are not way into the future, but we are coming up with a system to warn us over the next three months.”

These additional expenses that the SMEs must incur because of climate change raise the cost of doing business, which in turn makes products more expensive. This compromises the competitiveness of SME products relative to large companies, which have the benefit of economies of scale.

Some SMEs are finding that the shelf life of produce is negatively affected by the changing climate. Rising temperatures reduce the longevity of both perishable and packaged goods. Interviewee A4 has already replaced plastic packaging with paper cartons on beverage products. This has increased the product shelf life:

“*Two things about PET [plastic bottle] packaging: One, it's light. So the product does not really have longevity. It's short shelf life. It's very short because it’s light. Uh, that is part one. That affects general health. And otherwise, then the climate change part of it is it's plastic. So now how do we therefore eliminate plastic to be eco-friendly? Therefore, you do your carton packaging. It's expensive, but it's worth it because one, you are eco-friendly, you're saving the environment, and secondly, its shelf life is longer than PET. So it's a both-way, kind of benefits. So, nature benefits and, and you as a business, you benefit.”*

Similarly, interviewee A9 reported making changes to the packaging of products, in response to climate change:

“*We have made quite a lot of changes just in terms of our packaging, ensuring that we've got packaging that's environmentally friendly.”*

Environmentally friendly packaging reduces the amount of solid waste incinerated at landfills, thereby reducing greenhouse gas emissions.

Other SMEs are taking a value chain management approach to secure input supply in spite of climate change. This is through vertical integration, taking ownership or control of processes further upstream or downstream in the value chain. One such example is interviewee A10, who is engaging upstream, with the farmers who produce required inputs:

> "*We have collaborated with local, rural farmers from the village that I come from, wherein we go and source our fruits and vegetables…So we do not work with commercial farmers. We only work with rural organic, with rural emerging farmers. Reason being the products that we produced are organic."*

Interviewee A3 emphasised the importance of understanding the entire lifecycle of one's product, so as to better serve the retailers and users:

> *"I think it's always great as a producer to understand your product even way beyond, um, you know, the finished, uh, packaged product that sits on the shelves. It's really important to understand the entire value chain, especially as an agro-processor, because you are always acting as the middle person. You are in between the farmer and the retail space."*

On the other hand, some entrepreneurs prefer not to take a value chain management approach. They opt to focus on strengthening core processes instead of trying to integrate upstream or downstream. Interviewee A2 explained:

> "*So I would really like to move away from the planting sector. I don't want to own the whole value chain. I think we can do that through the whole community value chain. We can call it a community value chain, you know, and that's how we can all grow together. The bigger we grow as a business in terms of sustainability, the more their business becomes sustainable as well, because now they've got a bigger variety that they can plant, and they have an actual market to supply*."

This shows how either vertical integration or specialisation can be an adaptive strategy for dealing with climate change impacts on business. Which option is adopted depends on the attitude and aptitude and of the entrepreneur.

Several interviewees described investing in more appropriate production technology, conducting research and product development to use organic ingredients grown through alternative farming methods, and packaging products with recyclable or reusable materials.

5.7 Findings related to sub-question 3

The third research sub-question focussed on the future, rather than the present. The question assessed the perceived risks arising from climate change and the effect on agro-processing SMEs.

An overarching risk faced is that of maintaining operational resilience: the capacity of a business to proactively avert disruptions, promptly address them, and effectively recover from disturbances to its core operations.. It encompasses the complexities of risk management and compliance, illustrating the interconnected nature of these challenges. Table 6 presents the resulting axial codes and themes.

Table 6: Axial codes and themes relating to sub-question 3

Research sub-question 3	Axial codes	Theme
What risks arising from climate change do agro-processing SMEs identify?	difficulty meeting demand, compliance challenges, difficulty accessing finance	Operational risk
	water insecurity, food insecurity energy insecurity	Resource scarcity

5.7.1 Operational risk

Entrepreneurs foresee the current challenges with accessing sufficient quantity and quality of raw materials being exacerbated by climate change, posing further risk to business in the future. Vulnerabilities within supply chains and potential impact of climate change on production capacities will affect ability to meet market demand. Interviewee A5 expressed this concern:

> *"So…the type of challenges that I think as SMEs in future, we would face, is satisfying the market. You know, if one is unable to produce, that means that you cannot meet the market demand. I can't imagine a situation where I am now supplying retail markets and even exports, and I'm unable to keep up with supply due to the fact that there's no raw produce or quality raw produce."*

Compliance with food safety standards and other requirements of retailers and importers is a high priority issue for agro-processing SMEs, with some worried that

climate change may impact future ability to meet those standards. Furthermore, interviewees expressed concern about future access to financing for their businesses, because of lowered business viability due to climate change. Interviewee A5 expressed it this way:

> "…*a lot of businesses are aware that once they fund an [agro-processing] entrepreneur like myself, there would be a lot of risks, which are climate-based risks that could impact the business and therefore not being able to pay back loans. So it would definitely make it difficult for us as SMEs to access funding and investment for our businesses*."

Some interviewees reported taking steps to manage the climate related risks they are facing. This starts with a thorough understanding of the risks. Interviewee A2 explained:

> "*Firstly, what we have done, speaking from experience, is a risk assessment. We do not do any other thing or any other product. We conduct a comprehensive risk assessment to identify anything that may affect the supply chain due to the climate change…including extreme weather events*."

5.7.2 Resource scarcity

Agro-processors who grow own inputs seemed even more concerned about grappling with the delicate balance between production capacities and the availability of essential resources influenced by climate change. Specifically, there are concerns over water and energy insecurity, indicating the direct impact of climate change on the quantity and quality of critical resources available. Interviewee A9 had this to say:

> *"The major risks we see are, just in terms of the health of our crops, and our ability to produce larger volumes. So, you know, we can have the best processing facility and all these plans for expansion, but, um, without these crops…really our core business is around these crops. So, climate change poses a risk to our ability to upscale our cultivation."*

Overall, the interviewees expressed confidence in their ability to manage the business risks associated with climate change, or to pivot into a different line of business, should agro-processing no longer be viable. However, it is important from a societal perspective to maintain the viability of small businesses in the agro-

processing industry, to maintain food security and economic opportunity, particularly in the rural areas where several such businesses operate.

5.8 Findings related to sub-question 4

The fourth and final research sub-question examined opportunities arising from climate change as perceived by agro-processing SMEs. This question was of particular interest because, while climate change is normally perceived in a negative light, the literature suggests that it may have positive effects in particular contexts, or open up new business opportunities. Table 7 presents the resulting axial codes and themes.

Table 7: Axial codes and themes relating to sub-question 4

Research sub-question 4	**Axial codes**	**Theme**
What opportunities arising from climate change do agro-processing SMEs identify?	indigenisation, raising awareness, stakeholder management, health consciousness, strategic partnerships, support to SMEs	Stakeholder centricity
	positive climate effects, entrepreneurial behaviour, business expansion, differentiation	Entrepreneurial bricolage

5.8.1 Stakeholder centricity

Agro-processing SMEs identify opportunities in adopting stakeholder-centric strategies in response to climate change. This requires integration of stakeholder management into the core operations of the business, with a focus on health consciousness under a changing climate, driving a shift towards products and practices that support consumer well-being. Agro-processors see a role for themselves in educating consumers on climate change and how it will affect

availability of key resources such as water, food and energy. According to interviewee A5:

> *"…another thing which is very key…is information sharing. I think that will be one of the things that we can contribute to, in our company in future, where customers are made aware and we can also educate them about sustainability, and have also us letting them know of our packaging, our labelling, and getting some sort of feedback from them, and some sort of an engagement for them to be aware of the environmental benefits that we are contributing to, and why we are doing it. And so that they can also be aware of the need of reducing their environmental impact*."

Interviewee A2 expressed a similar viewpoint:

> "*Something we could also look into is, I'm not sure how big education and awareness is in the food and beverage space, because we have the opportunity to educate a lot of consumers about the environmental impact of their food choices*."

Furthermore, by creating products that help consumers maintain or improve health conditions under a changing climate, agro-processors can increase profitability while helping customers build resilience against the changing climate.

Interviewee A3 likened the impact of climate change on food preferences to her experience from the COVID-19 pandemic:

> *"Basically, ours is a COVID-born company inspired by the state in which the entire world was, had found itself during that time where everybody suddenly had to figure out how to stay healthy, and people were gravitating more towards natural products. And so we had to go back to basics. We had to remember what our parents, our grandparents were using as well And so we want to start now developing products that are a hundred percent natural, that are, in a sense, resistant to any climatic change."*

The interviewees see opportunity to benefit from a growing trend towards healthier food preferences, which is likely to become even more widespread as the climate changes. In areas that are projected to receive less rainfall, consumers may need to adapt food preferences towards products made from drought-resistant crops such as sorghum and millet, as opposed to water-thirsty crops such as rice, maize and

potatoes. Furthermore, under unpredictable climatic conditions, perennial crops that grow year-round may become preferable to seasonal crops as inputs into processed foods.

Agro-processors also recognise that to remain sustainable, the use of inputs that are indigenous to a specific area of operations will be critical for survival in the local climate conditions. As energy becomes more scarce, transporting agricultural produce across long distances will become less sustainable. Rising temperatures will also increase the need for use of refrigerated trucks, which are likely be expensive for SMEs. Thus, using indigenous local produce will be more attractive to them. Interviewee A9 has already recognised the value of using indigenous inputs:

> "*We've used this business as a way to develop rural communities, have them participating in the mainstream economy, while actually developing products out of indigenous [plants] in a way to also preserve those indigenous knowledge systems and document them*."

A further aspect of stakeholder centricity is effective engagement with suppliers, in this case, the farmers that produce raw materials. Some of the entrepreneurs interviewed have recognised a need to play a proactive role in empowering suppliers. Interview A10 sees this as an opportunity to safeguard future supply:

> "*In the future, we are going to incorporate a system or a programme wherein we incubate all our partners that we source our ingredients from. Then see how we can make their farms better in order to benefit us as well."*

Other opportunities to promote products arise through strategic partnerships that help to overcome or offset any negative impacts of climate change on business. Interviewee A3 seeks endorsement of her product by health and wellness professionals as a way to stoke demand:

> "*Going forward, we do want to look into forming strategic partnerships with various institutes. These would be from different professions. It could be paediatricians, it could be nutritionists, it could be homeopaths, as well as naturopaths, whom we would like to give an opinion, more of a vote of confidence, in this product. And that would also help in terms of enhancing the knowledge of this product that we are trying to share with, if we're lucky enough, with the world, with the entire world. So yes, we do look forward to investing a lot more in strategic partnerships in that regard."*

Several of the interviewees reported having received some form of government support to grow. There was confidence that the relevant government agencies can provide the knowledge and support needed to deal with climate change. Thus, the opportunity to work closer with these agencies is well recognised. Interviewee A9 acknowledged the support available to SMEs.

> "*In terms of external bodies, um, we are getting quite a lot of support already to develop these innovations, through institutions such as the CSIR and the Agricultural Research Council, and the Department of Science and Innovation, as well as Department of Fisheries, Forestry and Environment. So, there's a lot of support out there for small businesses. So even if you don't have all the skills internally, there are many external bodies for SMEs to gain support from."*

The role of the sector education and training authorities (SETAs) is recognised as key in providing SMEs with the skills and knowledge required to remain viable under a changing climate. Interviewee A4 expressed confidence in the support of the SETAs:

> *"In South Africa, we have the SETAs. In my sector, we have a SETA on food and beverage, as well as retail and wholesale SETA. So I am under those SETAs. So I know that even if one is having challenges financial wise, when it comes to skills, those are the SETAs that will assist us in any new skill that we need."*

Other supportive government agencies that the interviewees expressed confidence in were SEDA, the Gauteng Department of Agriculture and Rural Development (GDARD), the Eastern Cape Development Corporation (ECDC), Wesgro, and the Innovation Hub. Some interviewees also reported receiving guidance from industry bodies in various sub-sectors, as well as mentorship support from owners of larger companies.

5.8.2 Entrepreneurial bricolage

Several interviewees displayed the willingness and ability to use whatever resources are available to them in order to make new products. As climate change does not affect all areas in the same way, some interviewees reported how changes in rainfall

patterns have increased availability and variety of inputs for their production. Interviewee A8 said:

"I think the climate change is not a negative thing in every, not in every place in South Africa. The climate change has actually caused some places to have more rain than before. So now comes actually a more productive year for some of us, because of the more rain, like in our area."

Interviewee A6 described similar experience:

> "…*where I'm planting, I don't know if it is because of this climate change or what, but when I plant, I've got herbs…herbs just grow in my farm that I didn't know. They used to grow and then I would throw them out, you know, take them out thinking they were weeds. And people started telling me that this is medicine. Really? Medicine! Dandelion and cerasee, now I'm selling it. But what surprises me the most is that in winter, I could still get chilli…in winter, chilli is growing and I can still harvest*…"

Evidently, regional differences in climate impact should be researched and understood, so that entrepreneurs are guided to locate operations in the most suitable locations, where the inputs for business are readily available.

Furthermore, agro-processing entrepreneurs recognise that the changing climate is opening up new funding opportunities for them, particular for those who own land and farm inputs. Interviewee A9 described opportunities to attract funding through carbon offset schemes:

> "*I had a conversation with a lady who's promoting regenerative agriculture, and she made me aware that corporates are actually, especially corporates who are highly contributing towards carbon emissions, that they are looking at projects to fund that are having less of an impact, or that have actually more of a positive impact to the environment. So that way, they're funding those projects to kind of reduce their, how they're contributing. So like, for instance, I've heard of motor vehicle companies that are actually looking to fund small businesses and smallholder farmers that are more on the regenerative agriculture side. So yeah, there's different opportunities that emerge from that."*

Some interviewees expressed hope that in response to climate change, more research and development will go into indoor farming methods such as hydroponics, which will bring down the cost of the associated technologies. Interviewee A13 put it this way:

> *"Opportunity wise, I would say most probably, more hydroponics. So I am at the moment speaking to some hydroponic farmers. So hydroponics is where you can actually plant indoors. And you can have more control over the crops. And so the outside elements don't affect the crops. They would use things like special lighting…everything is done indoors. So when it comes to opportunities and producing food…people need to look at controlling the environment that food is grown in so that we can still produce. The downside of it is that the population is big and to grow food on a larger scale is not easy; it's quite expensive, when you use those type of farming methods."*

Some interviewees see the opportunity to diversify into related types of business, for example, becoming intermediary suppliers of raw materials to larger companies. Interviewee A7 is already experiencing this:

> *"At this stage I'm feeling that I've become the opportunity, because these big companies usually buy ingredients from other big companies, but now they don't have them. So now they've come to know these small businesses like us, and they ask me now, "Do you have the [ingredients]? I'm like, "Yes!" Okay. So it's an opportunity. And now even to my supplier from Malawi, now I can have the opportunity to say, "I want truckloads of [ingredients]."*

Ultimately, the interviewees expressed confidence in ability to either adapt to the changing climate, or to pivot into different lines of business. The entrepreneurial mindset that enabled them to build their current businesses stands them in good stead to respond effectively to any future challenges faced. Interviewee A11 said:

> *"…the thing about entrepreneurs is a hundred percent there's risks, whether it's climate change or anything else, there's always risks. But I think the, the underlying thing with entrepreneurs is that we are problem solvers. So regardless of what gets thrown at us and what the risks are, our livelihood is based on problem solving, and, you know, working around things like risks and problems…It's a matter of, once again, creating the opportunities for yourself if*

you're an entrepreneur, finding those opportunities and, and taking full advantage of them."

5.9 Summary of findings

Agro-processing SME owners reported increased difficulty in sourcing desired quantity and quality of inputs, as the main impact of climate change on business operations. In response to this challenge, producers are innovating by implementing sustainable production practices. This involves conducting research and development to come up with products that are viable under the evolving climatic conditions, using appropriate technology, alternative farming methods, as well as recyclable or reusable packaging. Several are integrating downstream and upstream activities along product value chains, to ensure sustainability at all levels.

Looking into the future, the interviewees foresee business risks such as difficulty meeting demand, challenges in accessing finance from regular sources such as banks, as well as s in complying with standards for retail and export, if the quantity and quality of inputs continues to decline due to climate change. It is also projected that societal risks such as water, energy and food insecurity will be prevalent.

On the other hand, entrepreneurs see opportunities arising from climate change as well. For instance, greater stakeholder engagement as consumers take more interest in the sources of their food and seek healthier options. As more people realise just how much the consumption of meat drives climate change, it is likely that the demand for vegan food options will rise. With their ability to pivot more easily than larger companies, SMEs can lead the return to indigenous vegan foods. They can also attract new forms of financing from socially responsible investors and carbon offset schemes.

Overall, the interviewees displayed the capacity to innovate in response to climate change, with the support of a network that fosters research and development, as well as access to finance. However, a concern is the slow business growth reported by two-thirds of the interviewees, because this could lead to them eventually leave the agro-processing industry to pursue other ventures. This could exacerbate food insecurity, particularly in the rural locations where several SMEs operate. An innovation ecosystem may be able to create the environment for such SMEs to survive and thrive under changing climatic conditions.

6. Discussion

6.1 Introduction

This chapter presents the discussion of the research findings reported in Chapter 5 compared with the literature review in Chapter 2. The research sub-questions outlined in Chapter 3 were used to structure this chapter. The themes identified from analysis of the axial codes and open codes are discussed in greater detail, each in relation to the relevant research sub-question.

6.2 Discussion of sub-question 1: What climate change impacts are agro-processing SMEs experiencing?

The main impacts of climate change on agro-processing SMEs were *input reliability challenges*.

The findings of the research indicate that climate change is already posing difficulty for agro-processing SMEs in obtaining the necessary inputs in desired quantities. The heightened unpredictability of weather patterns, attributed to climate change, is proving to be a hurdle, influencing production cycles and overall stability of firms. Difficulties faced in securing crucial ingredients has had a detrimental impact on the functioning of some ventures represented in the primary data. These disruptions in the supply chain cause production inefficiencies and challenges in meeting market demand for products.

Moreover, the increased frequency of extreme weather variations, linked to climate change, has led to a decline in the quality of inputs, ultimately affecting the overall quality of food products. SMEs also face the challenge of coping with rising prices for inputs, driven by increasing demand for a reducing quantity of quality agricultural produce in the market. Consequently, this has led to overall escalations in operational costs, significantly influencing the sustainability and competitiveness of businesses.

The differences in climatic conditions across various regions of South Africa have led to diverse challenges. The impact of climate change on input availability exhibits notable regional variations, with companies obtaining inputs from Limpopo and Mpumalanga showing better outcomes compared to those relying on sources from

other parts of South Africa. Interviewees from other provinces highlighted preference for sourcing inputs from Limpopo and Mpumalanga when faced with insufficient supply from within own provinces.

It was of interest to note that not all interviewees recognised current impacts of climate change on commercial activity. Some viewed it as relatively inconsequential compared to other more immediate concerns affecting businesses in South Africa. The experiences of interviewees indicate that the effects of climate change vary, potentially influenced by factors such as whether an agro-processing SME cultivates its own inputs, as well the geographical area from which inputs are sourced. Additionally, there is opacity that clouds ability to distinguish between the impacts of climate change and those arising from concurrent socio-economic issues, such as the electricity crisis and the aftermath of the COVID-19 pandemic.

These findings appear consistent with the literature. Durán-Sandoval et al. (2023) report observations that climate change is resulting in several agricultural commodities becoming less abundant and more costly. Scholes and Engelbrecht (2021) also predict a decline in the yield and viability of most agricultural produce in South Africa.

Across a significant portion of its territory, South Africa is already characterised by temperatures that are excessively warm or conditions that are overly dry, rendering it suboptimal for crop production. Continued warming and drying trends are expected to result in diminished yields across most crops and parts of the country (Scholes & Engelbrecht, 2021).

It is evident from both this study and extant literature that operating conditions are become more challenging for agro-processing SMEs in South Africa, as the quantity and quality of agricultural produce available declines due to the changing climate.

6.3 Discussion of sub-question 2: How are agro-processing SMEs innovating in response to climate change?

Agro-processing SMEs are innovating by adopting more *sustainable production methods* and undertaking *value chain management*.

The interview findings indicate that agro-processing SMEs are responding to climate change by adopting innovative solutions for more sustainable business models. These models not only address the risks arising from climate change but also contribute positively to social and environmental sustainability. As an example, instead of producing consistent quantities of each product, some SMEs have shifted to producing what is possible based on the availability of inputs from farmers.

Additionally, there are efforts to introduce product innovations that involve repurposing the waste generated during the production of primary products. This recycling approach in agro-processing serves to mitigate the impact of climate change. By reducing the amount of agricultural waste sent to landfills, it helps decrease the emission of greenhouse gases into the environment. Consequently, this contributes to a reduction in the greenhouse effect, a key factor in climate change.

Certain interviewees highlighted proactive approach in seeking input sources beyond local markets to obtain the desired quantities and quality. Some are even considering international business expansion instead of relying on imports. The interviewees who cultivate own inputs have expressed initiative to explore alternative farming methods that can ensure a consistent input supply amidst changing climatic conditions. Greenhouse farming has emerged as a particularly intriguing option in this regard. On the other hand, those interviewees who do not cultivate inputs are exploring the possibility of sourcing from farmers equipped with greenhouses as a means to guarantee both the quality and quantity of inputs.

Moreover, agro-processing SMEs engaged in own farming reported making investments in early warning technologies. This is aimed at providing advance notice of unfavourable weather conditions, to enable proactive intervention against potential losses. However, this creates extra expenses incurred by SMEs due to increased overall cost of operations. In turn, the outputs are more expensive, diminishing the competitiveness of SMEs' products compared with those manufactured by larger companies that benefit from economies of scale.

Certain SMEs have observed adverse effects on the shelf life of products due to the shifting climate. Elevated temperatures are a key factor in the diminished usability spans for both perishable and packaged goods. In response, some SMEs in the beverage industry have opted to replace plastic packaging with carton packaging, a

measure that extends the products' shelf life. Environmentally friendly packaging choices not only enhance the sustainability of the products but also contributes to a reduction in the amount of solid waste incinerated at landfills, lowering greenhouse gas emissions.

Some SMEs are adopting value chain management strategies to ensure stable input supply despite the challenges posed by climate change. This involves vertical integration, where companies take ownership or control of processes either upstream or downstream in the value chain. Some are collaborating upstream with farmers responsible for producing required inputs, while others underscore the importance of comprehending the entire lifecycle of their products to better serve retailers and users.

Conversely, some entrepreneurs opt not to pursue a value chain management approach. Instead, they focus on strengthening core business processes without integrating upstream or downstream. This demonstrates how either vertical integration or specialisation can serve as an adaptive strategy in response to the impacts of climate change on business.

The choice between these approaches depends on the interests and capabilities of the entrepreneur. Numerous interviewees described initiatives, such as investing in more suitable production technology, conducting research and product development utilizing organic ingredients from alternative farming methods, and packaging products with recyclable or reusable materials.

These findings indicate several positive steps that agro-processing SMEs are taking to become more sustainable, safeguard entrepreneurial ventures from climate change and avoid contributing towards it. Consistent with the literature, the SMEs that self-reported as fast-growing and highly profitable were the ones making the most progressive innovations (Alam et al., 2022).
For instance, using the waste from one process as an input into the production of another product can be considered as a form of circular economy. An approach in which materials cycle through the economy multiple times instead of merely being extracted, used and disposed of in a linear manner (Yang et al, 2021).

Adopting more eco-friendly packaging mitigates climate change by reducing the amount of non-recyclable waste that must be disposed of at landfills, as incineration

of waste at landfills emits greenhouse gases (Phelan et al., 2022). Such innovative actions by agro-processing SMEs also influences larger companies to take similar responsible action.

6.4 Discussion of sub-question 3: What risks arising from climate change do agro-processing SMEs identify?

The primary climate-related challenge confronting agro-processing SMEs lies in *sustaining operational resilience*. *Resource scarcity* is also recognised as a broader societal risk.

As outlined in the literature review, operational resilience refers to a business's capacity to prevent disruptions as much as promptly responding to and recovering from disturbances in its primary operations. This concept encompasses the intricacies of risk management and compliance, highlighting the interconnected nature of these challenges.

Entrepreneurs anticipate that existing difficulties in obtaining adequate quantity and quality of raw materials will be intensified by climate change, thereby increasing risks to commercial activity in the future. Challenges associated with meeting market demand, revealing vulnerabilities in supply chains and potential consequences of climate change on production capacities were highlighted.

Agro-processors who cultivate inputs express even greater apprehension. They grapple with a delicate equilibrium between production capacities and the availability of essential resources influenced by climate change, such as energy and water. Concerns were voiced about energy and water insecurity, underscoring the direct impact of climate change on the accessibility and quality of crucial resources.

Agro-processing SMEs place significant emphasis on adhering to food safety standards and meeting the requirements set by retailers and importers. Some express concerns that climate change might affect future capacity to comply with these standards. Additionally, there is apprehension among interviewees regarding the future availability of financing for business, as climate change could diminish overall business model viability. A number of interviewees have already initiated measures to address the climate-related risks they are encountering, beginning with comprehensive understanding of these risks.

In general, interviewees exhibit confidence in personal ability to navigate and mitigate the business risks associated with climate change. Readiness to adapt was expressed as either managing the challenges or transitioning into alternative business lines if agro-processing becomes unsustainable. However, maintaining the viability of small businesses in the agro-processing sector is deemed crucial from a societal standpoint. This is essential for sustaining food security and economic opportunities, particularly in rural areas where numerous small businesses are situated.

These findings are supported by the literature, which recognises that SMEs in African countries are especially vulnerable to the impacts of climate change, with this vulnerability leading to a higher overall level of climate risk (Simpson et al., 2021). The relatively unfavourable conditions for crop production, coupled with lower access to finance and technology, make small businesses in this region more vulnerable (Crick, Eskander et al., 2018).

One of the main ways in which climate change is experienced is through changes in the frequency, intensity and timing of rainfall (Scholes & Engelbrecht, 2021). These changes in precipitation patterns reduces water security, which in turn reduces food security (Durán-Sandoval et al., 2021). Thus, every effort must be made to better manage the production factors that are under human control, minimising potential societal effects of water and food insecurity.

6.5 Discussion of sub-question 4: What opportunities arising from climate change do agro-processing SMEs identify?

Stakeholder centricity and *entrepreneurial bricolage* are seen as avenues of opportunity.

Agro-processing SMEs perceive potential advantages in embracing stakeholder-centric approaches in response to climate change. This involves integrating stakeholder management into the core operations of the business, with particular emphasis on promoting health consciousness amid changing climate conditions. This shift entails a focus on products and practices that support consumer well-being. Agro-processors envision a role for themselves in educating consumers about climate change and its potential impact on crucial resources such as water, food, and

energy. This is consistent with entrepreneurship theory, which recognises community engagement as a catalyst for the growth of an enterprise (Fisher, 2012).

Moreover, by developing products that assist consumers in maintaining or improving health and wellness in the face of climate change, agro-processors can enhance profitability while aiding customers in building resilience against the evolving climate. Interviewees recognise the opportunity to capitalise on the growing trend towards healthier food preferences, which is expected to gain further traction with climate change. In regions projected to become drier, consumers may need to adapt food choices towards products derived from drought-resistant crops like sorghum and millet, rather than water-intensive crops such as rice, maize, and potatoes. Additionally, under unpredictable climatic conditions, perennial crops that grow year-round may become more preferable inputs for processed foods compared to seasonal crops.

Agro-processors also acknowledge the importance of using indigenous inputs to maintain sustainability in the face of climate change. As energy becomes scarcer and transporting agricultural produce over long distances less sustainable, the use of indigenous local produce becomes a more attractive option for SMEs.

Another facet of stakeholder centricity involves effective engagement with suppliers, particularly the farmers who provide essential raw materials. Some entrepreneurs interviewed recognised the need to play a proactive role in empowering suppliers, and reported proactively doing so, to spread needed knowledge to the farmers to secure inputs.

Opportunities also arise through strategic partnerships to promote products, helping offset potential negative impacts of climate change. Several interviewees reported receiving government support to expand operations and expressed confidence that relevant government agencies can provide the knowledge and support necessary to address climate change. There is opportunity to collaborate more closely with these agencies.

It is crucial to recognise that the impacts of climate change vary across different regions. Interestingly, some interviewees highlighted how shifts in rainfall patterns have increased the availability of inputs for choice products. Consequently, it is imperative to research and comprehend regional differences in climate impact. This

understanding will guide entrepreneurs to strategically locate operations in areas where necessary inputs are readily accessible.

Additionally, agro-processing entrepreneurs acknowledge that the evolving climate presents new funding opportunities, particularly for those who own land and cultivate inputs. For instance, emerging possibilities include attracting funding through carbon offset schemes. Some interviewees expressed optimism that, increased research and development for climate change mitigation will focus on indoor farming methods like hydroponics, potentially reducing associated technology costs. Others see the prospect of diversifying into related businesses, such as becoming intermediary suppliers of raw materials to larger companies.

The interviewees were confident in their capacity to either adapt to the changing climate or transition into different business models. The entrepreneurial behaviour with which they established their existing enterprises positions them well to respond effectively to any future challenges. Overall, the interviewees exhibit what can be termed as entrepreneurial bricolage – the willingness and ability to utilise available resources in addressing evolving business challenges and opportunities (Fisher, 2012).

Consequently, it is anticipated that entrepreneurs will continue to thrive in this industry for the foreseeable future, especially if supported by the enabling environment that an innovation ecosystem can create. This would ensure that SMEs can take advantage of the opportunities created by the rising demand for healthier and more climate-friendly diets, such as veganism (Saari et al, 2021); as well as technological advances being made in food systems around the world.

6.6 Discussion summary

Owner-managers of agro-processing SMEs have noted an increased challenge in procuring the desired quantity and quality of inputs as the main impact of climate change on their business operations. In response to this hurdle, proactive innovation to adopt sustainable practices is essential. This entails undertaking research and development to create products that remain viable under evolving climatic conditions. This entails employing appropriate technology, exploring alternative farming methods, and utilising recyclable or reusable packaging. Some SME owners are also

integrating into downstream and upstream elements along the product value chain to ensure sustainability at all levels.

Looking into the future, various business risks are anticipated if the quantity and quality of inputs continues to decline due to climate change. These include difficulties in meeting demand, accessing finance from traditional sources such as banks, and adhering to retail and export standards Societal risks such as water, energy, and food insecurity are also foreseen.

Nevertheless, there are opportunities stemming from climate change, such as increased stakeholder engagement as consumers express more interest in the sources of food and seek healthier options. The rising awareness of the environmental impact of meat consumption may lead to growing demand for vegan food options, providing SMEs with the agility to pivot more easily than larger companies and lead the return to indigenous vegan foods. This shift can also attract new forms of financing from socially responsible investors and carbon offset schemes.

However, a notable concern is the slow business growth reported by two-thirds of the interviewees, raising the prospect of them eventually leaving the agro-processing industry for other ventures. This could exacerbate food insecurity, particularly in rural locations where numerous SMEs operate. Establishing an innovation ecosystem may be imperative to sustain and foster the growth of SME enterprises in the future.

Innovation ecosystems are not only important for SMEs. Collaborating with SMEs can help larger companies to innovate, develop new products, and integrate into modified value chains quicker than by relying only on their internal R&D capabilities (Hakovirta et al., 2023). Thus, innovation ecosystems can be win-win partnerships for both large and small businesses. These findings are illustrated in Figure 7 below, which shows how the enabling environment of an innovation ecosystem can foster innovation through a variety of means, in response to the effects of climate change on business.

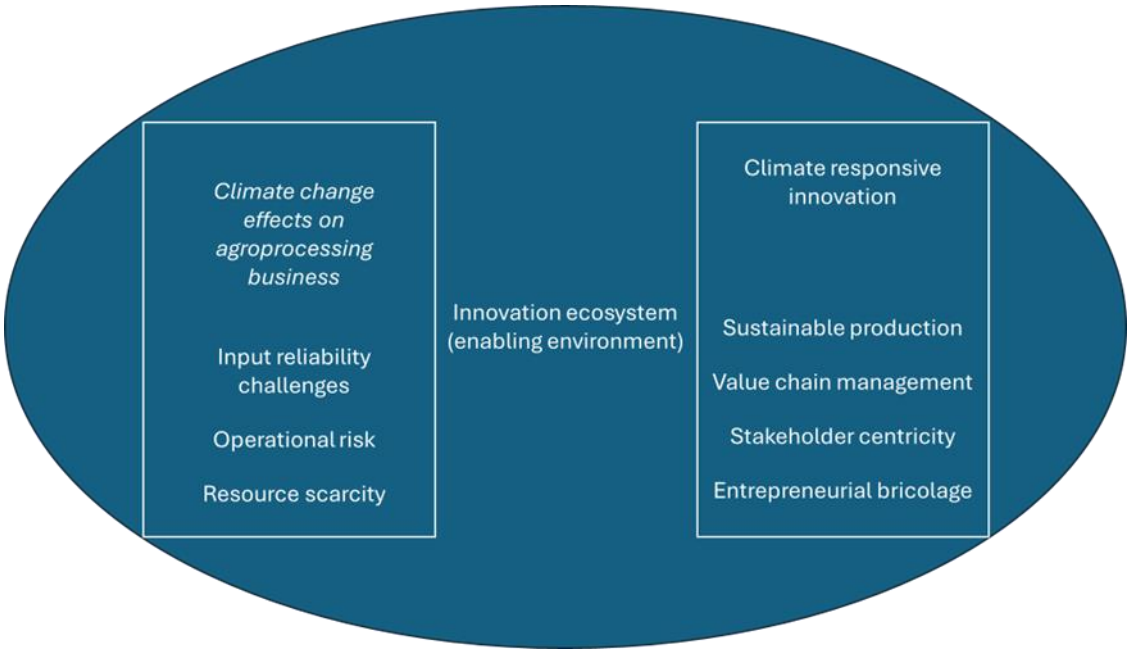

Figure 7: Innovative responses to climate change effects on business (Source: Author)

Figure 7, above, is composed of the themes that emanated from this study. It shows how that in the context of a supporting ecosystem, entrepreneurs experiencing various effects of climate change on their businesses can take innovative action to safeguard their business viability as well as take advantage of emergent opportunities. Such opportunities include expanded markets for their goods, as demand increases in areas where the goods have become scarce due to climate change, as well as cost savings through increased resource-use efficiency, enhanced collaboration along the product value chain, and improved reputation and brand recognition for businesses that are seen to be taking action against climate change (Tall et al., 2021).

Finally, all the climate-responsive innovations proposed in Figure 5 (in chapter 2) were cited in some form by the respondents, with the exception of weather-proofing buildings. This is an additional adaptation measure that can be looked into by SMEs whose facilities are located in areas highly susceptible to adverse weather events such as flash floods and storm surges.

7. Conclusion and recommendations

7.1 Introduction

This section presents concluding statements that summarise the key insights from the study. The discussion integrates the primary data findings with existing literature to form a coherent set of conclusions that address the research questions. Additionally, it provides recommendations to stakeholders, encompassing practitioner implications derived from the research findings, as well as a contribution to the academic debate on the topic. This chapter also outlines the study's limitations and suggests areas for future research.

7.2 Summary of principal conclusions

This study explored whether and how SMEs in the South African agro-processing industry innovate in response to climate change, so as to determine what enabling environment is needed for them to be more innovative. This is important because the research and business communities have a good understanding of how climate change affects agriculture, but less about the effects higher up in the food and beverage value chain (Zurek et al., 2022). Fifteen owner-managers of agro-processing SMEs in food and beverage production were interviewed to understand current experiences with climate change impacts. Data on any actions being taken in response, as well as perceptions of future climate-related risks and opportunities was captured. The responses were coded and subjected to thematic analysis.

The first research sub-question interrogated the climate change impacts on agro-processing SMEs in South Africa. Several interviewees reported that climate change is already making it difficult for them to source agricultural inputs of the desired quantity and quality. This was consistent with the literature on this matter, which indicates that the quality and quantity of agricultural produce in the Southern African regions is expected to decline due to climate change (Scholes and Engelbrecht, 2021).

This has important implications for food security in the region, because South Africa is a major producer of manufactured food and beverage products in the Southern African region and beyond. A decline in food production would have negative economic impacts not only for South Africa but also for its neighbouring countries.

Therefore, inhabitants of the Southern African region ought to be prepared for escalating food prices, as food manufacturers encounter more difficulties in sourcing inputs, or pivot into other lines of business, leading to food shortages. Society also needs to be prepared to make dietary changes, as crops that require high amounts of water to grow become less viable in South Africa, and climatic conditions become less favourable for livestock production.

Another important consideration is the amount of investment that has already gone into technology that might no longer be viable to operate in future. For example, as the Western Cape becomes less suitable for growing grapes, the centuries of investment into wine production facilities may go to waste. These are important considerations for the future viability of the food and beverage industry's contribution to the South African economy.

On the positive side, some parts of South Africa may experience increasing rainfall and thus greater production of some of the inputs needed by agro-processing SMEs. However, flooding becomes a major risk in such areas and might cause unexpected crop losses. This necessitates early warning systems that can provide information on extreme weather events in advance. It also necessitates the relocation of farming activities away from flooding hotspots.

In such uncertain times, entrepreneurs will need a shared source of credible information and guidance. Industry bodies have a very important role of conducting and disseminating research to guide members on the changes expected, and how to innovate in order to remain viable. Government bodies that support SME development also ought to incorporate climate change awareness and preparedness into the advisory services provided to agro-processing SMEs. Sources of financing for SMEs also ought to be aware of the changing conditions under which these businesses are operating, in order to tailor financial products and services accordingly.

A key recommendation is that under a changing climate, agro-processing SMEs will only survive and grow through innovation. Innovation occurs within an enabling environment, which can be established by creating a supportive *innovation ecosystem*, comprising government, universities and other research institutes, industry bodies, consumer associations, financial services providers, corporate

entities and the SMEs themselves (Granstrand & Holgersson, 2020). An innovation ecosystem can foster sharing of knowledge, as well as joint research and development.

Mentorship opportunities between leaders of larger and smaller businesses could also be fostered in such a collaborative environment (Vahedna, 2019). For agro-processing entrepreneurs to remain viable under a changing climate, support is required from all stakeholders, to access the knowledge, resources and networks needed to foster innovation.

The second research sub-question pursued insight into how agro-processing SMEs are innovating in response to climate change. The main findings were that some are doing so through adopting more sustainable production processes. Others take a whole value chain approach towards managing climate risk. This entails considering the impacts of climate change before inputs reach them, i.e. during the agricultural production phase, and after products leave the factories, i.e. during transportation and retail. Supporting supplier famers to implement more sustainable farming methods, as well as replacing packaging materials with more sustainable ones, helps with both mitigating of and adaptation to climate change (Phelan et al., 2022; Zurek et al., 2022). Both of these changes are forms of innovation and introduce beneficial change into a particular context (Khan, 2018).

The third research sub-question was about agro-processing SME owner-managers' perception of future climate-related risk. The interviewees expressed concern about the likelihood of increased water and food insecurity, which can affect society at large, in addition to making it more difficult for businesses to operate profitably. Participants cited potential difficulty in meeting standards for retail and export, should access to high-quality inputs be compromised. Concern was also expressed over potential difficulties in accessing finance, if the industry was to become less profitable due to climate change impacts.

It would be to the detriment of the whole society and economy if access to food and beverages became more expensive, e.g. due to importation to supplement dwindling local production. Therefore, an innovative ecosystem for agro-processors, in which financial services providers are also involved, would help secure access to finance for businesses that are in a growth phase. Recognising risk as a function of hazard, risk and vulnerability, agro-processing SMEs can take actions to reduce exposure to climate risk. This may entail relocating facilities or changing where to source inputs

and reduce dependency on impacted suppliers. Additionally, adopting energy efficiency, water conservation and zero-waste technologies and practices can foster better use of available resources (Simpson et al., 2021).

The fourth research sub-question sought to gain insight into the opportunities agro-processing SMEs are identifying, emanating from the changing climate. Although climate change is associated with negative impacts due to higher frequency and intensity of extreme weather events and exacerbation of unfavourable weather conditions (Scholes and Engelbrecht, 2021), there is potential for some businesses to exploit opportunities arising from these changes.

Participants in this study highlighted expanded stakeholder engagement as an opportunity, because of increased interest in how food is sourced and produced, and the environmental impact thereof (Zurek et al., 2022). Consumers are increasingly seeking healthier food with a lower environmental impact, hence the trend towards veganism (Saari et al., 2021) on the rise in South Africa and globally.

SMEs tend to be early adopters of new trends. They have the agility to pivot into new product lines, due to lower level investment in producing any particular product compared to larger firms (Pinkse & Kolk, 2010). This places agro-processing SMEs in a good position to take advantage of the rising demand for vegan food, as well as other emerging food preferences such as that for organically-produced food.

The entrepreneurs interviewed expressed confidence in the ability to manage viable agro-processing SMEs even as the climate changes. There is willingness and ability to make best use of whatever resources are at hand, and to influence the supply chain both upstream and downstream, for continued success.

However, what several of them lack are access to climate information that can influence investment decisions, as well the resources to invest in research and development. These needs could be met through an innovation ecosystem that links all relevant stakeholders in this critically important industry.

Thus, in response to the overarching research question about what operating environment is needed for agro-processing SMEs to innovate more in response to climate change, this study found that a formalised innovation ecosystem, comprising the SMEs, corporates in their industry, research institutes and universities, industry bodies, financial services providers and consumer associations, could provide the access to information, finance and networks that the SMEs need in order to withstand

the negative impacts of climate change on their industry, through innovative climate change responses.

7.3 Academic contribution of the research findings

This study makes substantive contribution to scholarly discourse pertaining to the adaptive capacities of SMEs in the context of a dynamically changing climate. It probes the potential for innovation in products, processes, and supply chains as a mechanism for SMEs to navigate these challenges (Crick, Eskander et al., 2018; Alam et al., 2022). The ongoing debate questions whether innovation spurred by the private sector will suffice to counterbalance the adverse impacts of climate change. Alternatively there may be need for legislative and regulatory interventions to enforce compliance with environmental performance standards (Potluri & Phani, 2022; van den Bergh, 2013) aligned with the latest scientific insights into climate change.

The findings indicate that agro-processing SMEs in South Africa have several capacities to mitigate and adapt to climate change, but lack access to knowledge and finance that would support effectively doing so. The establishment of an innovation ecosystem for agro-processors could create the enabling environment needed by SMEs in this industry to remain viable as the climate changes. Self-directed action within a supportive framework is the way forward for climate response, rather than legislation and regulation.

Referring to the research gaps identified in Table 1, this study undertook qualitative analysis to corroborate the quantitative study by Alam, Du, Rahman, Yazdifar and Abbasi (2022), providing additional evidence that SMEs in developing countries innovate in response to climate change. The study also explored further how climate risk influences SMEs' investment decisions, finding that SMEs do invest in both climate change mitigation and adaptation (Crick, Eskander et al., 2018). The roles of the various institutions in the existing non-formalised, generic ecosystem in the agro-processing industry were discussed (Durán-Sandoval et al., 2023; Hakovirta et al., 2023). The value of formalising innovation ecosystems in a developing country context (Granstrand & Holgersson, 2020) was confirmed.

7.4 Business contribution of the research findings

Due to its pivotal role as a key player in food and beverage production and export in the region, South Africa's agricultural output holds substantial implications for both local and global food security. This vulnerability has a direct ripple effect on agro-processors within the country, who are confronted with heightened difficulties in securing essential ingredients for production. Unlike larger corporations operating in the food and beverage industry, many of which are publicly listed and obligated to monitor and disclose environmental performance, SMEs operate without such reporting requirements. Consequently, smaller firms are less aware of environmental threats, such as those posed by climate change.

Given the critical role that agro-processing SMEs play in upholding food security in South Africa, this research endeavoured to explore how these entities are grappling with multifaceted challenges exacerbated by climate change. It identifies the strategies SMEs are employing to secure viability and manage the climate-related risks and opportunities on the horizon.

7.5 Limitations of the study

A primary limitation stemmed from the employ of a single research method, thereby curtailing opportunity to triangulate findings through alternative methods. The confined duration available in which to complete the study and the researcher's limited prior contact with business owners in the industry under study made the research process difficult, as a significant proportion of the time was spent pursuing potential respondents.

Furthermore, the generalisability of the findings is hampered by the small sample size. This limitation could impact the external validity of the findings, particularly when examining responses to phenomena such as climate change, which exhibit varying impacts in different locations.

7.6 Recommendations for future research

Research on the impacts of climate change on small businesses in developing countries is still limited, and exploration of firm-level capacities to innovate even more so. Further research into the nature of enabling conditions for innovation in the food and beverage

sector under a changing climate could be undertaken quantitatively. This would enable capture of input from a larger sample size and facilitate analysis of how various factors influence one another.

Furthermore, as this study focused on one industry only, namely agro-processing, which is part of the manufacturing sector, future research could explore innovation for climate change response in other climate-sensitive sectors, such as such as transportation, construction and energy.

References

Adhikari, B., & Chalkasra, L. S. S. (2023). Mobilizing private sector investment for climate action: enhancing ambition and scaling up implementation. *Journal of Sustainable Finance & Investment, 13*(2), 1110-1127. https://doi.org/10.1080/20430795.2021.1917929

Alam, A., Du, A. M., Rahman, M., Yazdifar, H., & Abbasi, K. (2022). SMEs respond to climate change: Evidence from developing countries. *Technological Forecasting and Social Change*, *185*, 122087. https://doi.org/10.1016/j.techfore.2022.122087

Alaye, A. (2023). Comparative Assessment of Climate Change Response in Lagos, Nigeria and KwaZulu Natal Province, South Africa. *African Journal of Public Administration and Environmental Studies, 2*(2), 89-107. https://hdl.handle.net/10520/ejc-aa_ajopaes_v2_n2_a5

Baarsch, F., Granadillos, J. R., Hare, W., Knaus, M., Krapp, M., Schaeffer, M., & Lotze-Campen, H. (2020). The impact of climate change on incomes and convergence in Africa. *World Development*, *126*, 104699. https://doi.org/10.1016/j.worlddev.2019.104699

Bacon, E., Williams, M. D., & Davies, G. (2020). Coopetition in innovation ecosystems: A comparative analysis of knowledge transfer configurations. *Journal of Business Research, 115*, 307-316. https://doi.org/10.1016/j.jbusres.2019.11.005

Bogodistov, Y., & Wohlgemuth, V. (2017). Enterprise risk management: a capability-based perspective. *The Journal of Risk Finance, 18*(3), 234-251. https://www.proquest.com/scholarly-journals/enterprise-risk-management-capability-based/docview/1906146458/se-2?accountid=14717

Boucher, O., Forster, P. M., Gruber, N., Ha-Duong, M., Lawrence, M. G., Lenton, T. M., & Vaughan, N. E. (2014). Rethinking climate engineering categorization in the context of climate change mitigation and adaptation. *Wiley Interdisciplinary Reviews: Climate Change, 5*(1), 23-35. https://doi.org/10.1002/wcc.261

Budden, P., & Murray, F. (2022). Strategically engaging with innovation ecosystems. *MIT Sloan Management Review, 63*(4), 1-7.

https://www.proquest.com/scholarly-journals/strategically-engaging-with-innovation-ecosystems/docview/2700397936/se-2?accountid=14717

Chitonge, H. (2021). *The Agro-processing Sector in the South African Economy: Creating Opportunities for Inclusive Growth*. Policy Research on International Services and Manufacturing (PRISM) Working Paper 2021-4. University of Cape Town. https://commerce.uct.ac.za/sites/default/files/content_migration/commerce_uct_ac_za/869/files/PRISM%2520Working%2520Paper%25202021-4%2520-%2520Chitonge.pdf

Cresswell, J. W., & Cresswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE.

Crick, F., Eskander, S. M., Fankhauser, S., & Diop, M. (2018). How do African SMEs respond to climate risks? Evidence from Kenya and Senegal. *World Development*, *108*, 157-168. https://doi.org/10.1016/j.worlddev.2018.03.015

Crick, F., Gannon, K. E., Diop, M., & Sow, M. (2018). Enabling private sector adaptation to climate change in sub-Saharan Africa. *Wiley Interdisciplinary Reviews: Climate Change, 9*(2), 505. https://doi.org/10.1002/wcc.505

Department of Trade, Industry and Competition (2022). *Programme Guidelines: Agro-processing Support Scheme*. http://www.thedtic.gov.za/wp-content/uploads/APSS-Guidelines_Amendments.pdf

Dinesh, D., Hegger, D. L., Klerkx, L., Vervoort, J., Campbell, B. M., & Driessen, P. P. (2021). Enacting theories of change for food systems transformation under climate change. *Global Food Security, 31*, 100583. https://doi-org.uplib.idm.oclc.org/10.1016/j.gfs.2021.100583

Dlamini, L. (2022). *Understanding the organisational capabilities required for MSMEs to adopt circular economy business models* [Master of Business Administration mini-dissertation, Gordon Institute of Business Science]. University of Pretoria. https://repository.up.ac.za/handle/2263/90866

Drucker, P. F. (2002). The Discipline of Innovation. *Harvard Business Review, 80*(8), 95-102. https://hbr.org/2002/08/the-discipline-of-innovation

Durán-Sandoval, D., Uleri, F., Durán-Romero, G., & López, A. M. (2023). Food, Climate Change, and the Challenge of Innovation. *Encyclopedia, 3*(3), 839-852. https://doi.org/10.3390/encyclopedia3030060

Fisher, G. (2012). Effectuation, causation, and bricolage: A behavioral comparison of emerging theories in entrepreneurship research. *Entrepreneurship theory and practice, 36*(5), 1019-1051. https://doi.org/10.1111/j.1540-6520.2012.00537.x

Farooq, M. S., Uzair, M., Raza, A., Habib, M., Xu, Y., Yousuf, M., Yang, S. H., & Ramzan Khan, M. (2022). Uncovering the research gaps to alleviate the negative impacts of climate change on food security: a review. *Frontiers in plant science, 13*, 927535. https://doi.org/10.3389/fpls.2022.927535

Flick, U. (2018). *Designing Qualitative Research* (2nd ed.). SAGE. https://doi.org/10.4135/9781529622737

Funder, M., & Dupuy, K. (2022). Climate finance coordination from the global to the local: Norm localization and the politics of climate finance coordination in Zambia. *The Journal of Development Studies, 58*(10), 1899-1916. https://doi.org/10.1080/00220388.2022.2055467

Giglio, S., Kelly, B., & Stroebel, J. (2021). Climate finance. *Annual Review of Financial Economics*, *13*, 15-36. https://doi.org/10.1146/annurev-financial-102620-103311

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation, 90*, 102098. https://doi.org/10.1016/j.technovation.2019.102098

Hakovirta, M., Kovanen, K., Martikainen, S., Manninen, J., & Harlin, A. (2023). Corporate net zero strategy—Opportunities in start-up driven climate innovation. *Business strategy and the environment, 32*(6), 3139-3150. https://doi.org/10.1002/bse.3291

Harrison, N. E., & Mikler, J. (2014). An Introduction to Climate Innovation. In *Climate Innovation: Liberal Capitalism and Climate Change* (pp. 1-18). Palgrave Macmillan. https://link.springer.com/chapter/10.1057/9781137319890_1

Intergovernmental Panel on Climate Change. (2012). Glossary of terms. In C. B. Field, 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, & P. M. Midgley (Eds.), *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* (pp. 555-564). Cambridge University Press. https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf

Jacob, S. A., & Furgerson, S. P. (2012). Writing Interview Protocols and Conducting Interviews: Tips for Students New to the Field of Qualitative Research. *The Qualitative Report*, *17*(42), 1-10. http://nsuworks.nova.edu/tqr/vol17/iss42/3

Johannesburg Stock Exchange. (2022*). Leading the way for a better tomorrow – JSE Climate Disclosure Guidelines*. https://www.jse.co.za/our-business/sustainability/jses-sustainability-and-climate-disclosure-guidance

Kahn, K.B. (2018). Understanding innovation. *Business Horizons, 61*(3), 453-460. https://doi.org/10.1016/j.bushor.2018.01.011

Keenan, J. M., Chu, E., & Peterson, J. (2019). From funding to financing: perspectives shaping a research agenda for investment in urban climate change adaptation. *International Journal of Urban Sustainable Development, 11*(3), 297-308. https://doi.org/10.1080/19463138.2019.1565413

Kiger, M. E., & Varpio, L. (2020): Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*. https://doi.org/10.1080/0142159X.2020.1755030

Kuzma, S., Saccoccia, L., and Chertock, M. (2023, August 16*).* 25 Countries, Housing One-quarter of the Population, Face Extremely High Water Stress [Online news article]. *World Resources Institute*. https://www.wri.org/insights/highest-water-stressed-countries

Lee, T., Yang, H., & Blok, A. (2020). Does mitigation shape adaptation? The urban climate mitigation-adaptation nexus. *Climate Policy, 20*(3), 341-353. https://doi.org/10.1080/14693062.2020.1730152

Matos, S., Viardot, E., Sovacool, B. K., Geels, F. W., & Xiong, Y. (2022). Innovation and climate change: A review and introduction to the special issue. *Technovation, 102612*. https://doi.org/10.1016/j.technomorevation.2022.102612

McCracken, G. (1988). *The long interview* (Vol. 13). SAGE. https://doi.org/10.4135/9781412986229

Moore, J. F. (1993). *Predators and prey: A new ecology of competition*. Harvard Business Review, May-June (pp. 75-86). https://hbr.org/1993/05/predators-and-prey-a-new-ecology-of-competition

Muhaise, H., Ejiri, A. H., Muwanga-Zake, J. W. F., & Kareyo, M. (2020). The Research Philosophy Dilemma for Postgraduate Student Researchers. *International Journal of Research and Scientific Innovation*, *7*(4), 2321-2705. https://shorturl.at/gkGS4

Nyiwul, L. (2021). Innovation and adaptation to climate change: Evidence from the water sector in Africa. *Journal of Cleaner Production, 298*, 126859. https://doi.org/10.1016/j.jclepro.2021.126859

Organisation for Economic Cooperation and Development. (2023). *Climate Finance Provided and Mobilised by Developed Countries in 2013-2021: Aggregate trends and opportunities for scaling up adaptation and mobilised private finance*. OECD Publishing. https://www.oecd.org/finance/climate-finance-provided-and-mobilised-by-developed-countries-in-2013-2021-e20d2bc7-en.htm

Pearce-Higgins, J. W., Antão, L. H., Bates, R. E., Bowgen, K. M., Bradshaw, C. D., Duffield, S. J., & Morecroft, M. D. (2022). A framework for climate change adaptation indicators for the natural environment. *Ecological indicators, 136,* 108690. https://doi.org/10.1016/j.ecolind.2022.108690

Phelan, A. A., Meissner, K., Humphrey, J., & Ross, H. (2022). Plastic pollution and packaging: Corporate commitments and actions from the food and beverage sector. *Journal of Cleaner Production, 331*, 129827. https://doi.org/10.1016/j.jclepro.2021.129827

Pinkse, J., & Kolk, A. (2010). Challenges and trade-offs in corporate innovation for climate change. *Business Strategy and the Environment, 19*(4), 261-272. https://doi.org/10.1002/bse.677

Pollo, R., & Trane, M. (2021). Adaptation, Mitigation, and Smart Urban Metabolism towards the Ecological Transition. In C. Sposito (Ed.), *Possible and Preferable*

Scenarios of a Sustainable Future: Towards 2030 and Beyond, (pp. 74-89). https://doi.org/10.19229/978-88-5509-232-6/552021

Potluri, S., & Phani, B. V. (2022). Green Entrepreneurship: A Disruptive Mitigation Strategy for Climate Change. In W.-Y. Chen, T. Suzuki, & M. Lackner (Eds.), *Handbook of Climate Change Mitigation and Adaptation* (pp. 3787-3819). Springer. https://www.researchgate.net/profile/Seema-Potluri/publication/354143269_Green_Entrepreneurship_A_Disruptive_Mitigation_Strategy_for_Climate_Change/links/6127358038818c2eaf5f04d3/Green-Entrepreneurship-A-Disruptive-Mitigation-Strategy-for-Climate-Change.pdf

Princeton, B., Preetha, S., & Prathap, L. (2022). Awareness On Recent Trends of Global Climate Change. *Journal for Educators, Teachers and Trainers*, *13*(6), 153-163. https://dialnet.unirioja.es/servlet/articulo?codigo=8787197

Rabinowitz, H. S., Dahodwala, S., Baur, S., & Delgado, A. (2023). Availability of state-level climate change projection resources for use in site-level risk assessment. Frontiers in Environmental Science, 11(PNNL-SA-180244). https://doi.org/10.3389/fenvs.2023.1206039

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. *International Journal of Educational Investigations*, *3*(8), 51-59. http://www.ijeionline.com/attachments/article/57/IJEI.Vol.3.No.8.05.pdf

Republic of South Africa. (1996). Act No. 102 of 1996: National Small Business Act. *Government Gazette, 377*(17612). https://www.gov.za/sites/default/files/gcis_document/201409/act102of1996.pdf

Saari, U. A., Herstatt, C., Tiwari, R., Dedehayir, O., & Mäkinen, S. J. (2021). The vegan trend and the microfoundations of institutional change: A commentary on food producers' sustainable innovation journeys in Europe. *Trends in food science & technology*, 107, 161-167. https://doi.org/10.1016/j.tifs.2020.10.003

Sage. (2023, December 4). *SMEs struggling to report and act on sustainability, despite rising pressure* [Online press release]. https://www.sage.com/en-za/news/press-releases/2023/12/smes-struggling-to-report-and-act-on-sustainability-despite-rising-pressure/

Saunders, M., & Lewis, P. (2018). *Doing research in business and management: An essential guide to planning your project* (2nd ed.). Pearson Education.

Sautner, Z., Van Lent, L., Vilkov, G., & Zhang, R. (2023). Firm-level climate change exposure. *The Journal of Finance, 78*(3), 1449-1498. https://doi.org/10.1111/jofi.13219

Scholes, R., & Engelbrecht, F. (2021). *Climate impacts in southern Africa during the 21st Century.* Report for Earthjustice and the Centre for Environmental Rights. University of the Witwatersrand, Global Change Institute. https://cer.org.za/wp-content/uploads/2021/09/Climate-impacts-in-South-Africa_Final_September_2021.FINAL_.pdf

Sibiya, N. P., Das, D. K., Vogel, C., Mazinyo, S. P., Zhou, L., Kalumba, M. A., Sithole, M., Adom, R. K., & Simatele, M. D. (2023). Overcoming Bureaucratic Resistance: An Analysis of Barriers to Climate Change Adaptation in South Africa. *Climate*, *11*(7), 145. https://doi.org/10.3390/cli11070145

Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., & Trisos, C. H. (2021). A framework for complex climate change risk assessment. *One Earth, 4*(4), 489-501. https://doi.org/10.1016/j.oneear.2021.03.005

Small Enterprise Development Agency. (2023). *SMME Quarterly Update, 3rd Quarter 2022*. http://www.Small Enterprise Development Agency.org.za/Publications/Publications/SMME%20Quarterly%202022-Q3%20(005).pdf

South African Weather Service. (2017). A Climate Change Reference Atlas. https://www.weathersa.co.za/Documents/Climate/SAWS_CC_REFERENCE_ATLAS_PAGES.pdf

Stolker, R. J. M., Karydas, D. M., & Rouvroye, J. L. (2008). A comprehensive approach to assess operational resilience. In *Proceedings of the third resilience engineering symposium* (No. 2005, pp. 247-253). https://www.resilience-engineering-association.org/download/resources/symposium/symposium-2006/Stolker_Karydas_Rouvroye_text.pdf

Stoll, P. P., Pauw, W. P., Tohme, F., & Gruening, C. (2021). Mobilizing private adaptation finance: lessons learned from the Green Climate Fund. *Springer: Climatic Change, 167*(3-4), 45. https://doi.org/10.1007/s10584-021-03190-1

Su, H. N., & Moaniba, I. M. (2017). Does innovation respond to climate change? Empirical evidence from patents and greenhouse gas emissions. *Technological Forecasting and Social Change, 122*, 49-62. https://doi.org/10.1016/j.techfore.2017.04.017

Tall, A., & Brandon, C. J. (2019). *The World Bank Group's Action Plan on Climate Change Adaptation and Resilience : Managing Risks for a More Resilient Future.* World Bank Group. http://documents.worldbank.org/curated/en/519821547481031999/The-World-Bank-Groups-Action-Plan-on-Climate-Change-Adaptation-and-Resilience-Managing-Risks-for-a-More-Resilient-Future

Tall, A., Lynagh, S., Blanco Vecchi, C., Bardouille, P., Montoya Pino, F., Shabahat, E., Stenek, V., Stewart, F., Power, S., Paladines, C., Neves, P., & Kerr, L. (2021). *Enabling Private Investment in Climate Change Adaptation and Resilience: Current Status, Barriers to Investment and Blueprint for Action.* World Bank. https://doi.org/10.1596/35203

Thatch, L. (2023, November 11). Climate Change Propels France To #1 Largest Global Wine Producer in 2023 [online magazine article]. *Forbes*. https://www.forbes.com/sites/lizthach/2023/11/11/climate-change-propels-france-to-1-largest-global-wine-producer-in-2023/?sh=24252df3fcf3

Todaro, N. M., Testa, F., Daddi, T., & Iraldo, F. (2020). The influence of managers' awareness of climate change, perceived climate risk exposure and risk tolerance on the adoption of corporate responses to climate change. *Business Strategy and the Environment, 30*(2), 1232-1248. https://doi.org/10.1002/bse.2681

United Nations. (1992). *United Nations Framework Convention on Climate Change.* https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.* https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

United Nations Framework Convention on Climate Change. (2016). *The Paris Agreement.* https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

Vahedna, S. (2019). *Nature and perceived value of mentoring for established business owner-managers in South Africa* [Master of Business Administration mini-dissertation, Gordon Institute of Business Science]. University of Pretoria. https://repository.up.ac.za/handle/2263/74034

van den Bergh, J. C. (2013). Environmental and climate innovation: Limitations, policies and prices. *Technological Forecasting and Social Change, 80*(1), 11-23. https://doi.org/10.1016/j.techfore.2012.08.004

Winkler, H., Keen, S., & Marquard, A. (2021). *Policy approaches to guide finance flows for more effective climate action in South Africa*. University of Cape Town. https://zivahub.uct.ac.za/articles/report/Policy_approaches_to_guide_finance_flows_for_more_effective_climate_action_in_South_Africa/14963157

World Bank. (n.d., 2024, February 12). *World Bank Data: South Africa.* [Webpage]. https://data.worldbank.org/country/ZA

World Economic Forum. (2023). *Accelerating Business Action on Climate Change Adaptation – White Paper*. https://www.weforum.org/whitepapers/accelerating-business-action-on-climate-change-adaptation/

Yang, M., Chen, L., Wang, J., Msigwa, G., Osman, A. I., Fawzy, S., & Yap, P. S. (2023). Circular economy strategies for combating climate change and other environmental issues. *Environmental Chemistry Letters, 21*(1), 55-80. https://link.springer.com/article/10.1007/s10311-022-01499-6

Zilberman, D., Lipper, L., McCarthy, N., & Gordon, B. (2018). Innovation in response to climate change. In L. Lipper, N. McCarthy, D. Zilberman, S. Asfaw, & G. Branca (Eds.), *Climate smart agriculture: building resilience to climate change* (pp.49-74). Springer. https://doi.org/10.1007/978-3-319-61194-5

Zurek, M., Hebinck, A., & Selomane, O. (2022). Climate change and the urgency to transform food systems. *Science, 376*(6600), 1416-1421. https://www.science.org/doi/10.1126/science.abo2364

Appendices

Appendix A: Semi-structured interview guide

This interview is intended to gather information about climate change-induced innovations implemented by your company. The interviewer is seeking to understand how small-sized food and beverage manufacturing companies respond to climate change.

The interview will take approximately 30 minutes.

Questions:

1. Please tell me about your company– its products, processes and supply chain. How would you characterise its growth rate and profitability?

2. How is climate change affecting your company?

3. What risks do you foresee for the future viability of your company, related to climate change?

4. What opportunities do you foresee for you company, arising from the changing climate?

5. What skills are available to you, within your company or externally, to innovate in response to the climate change impacts that you are experiencing?

6. What changes have you made, or are you considering making, to your products, processes or supply chain in response to climate change?

Appendix B: Consistency matrix

Research sub-question	Supporting literature	Data collection tool	Means of analysis
1. What climate impacts are agro-processing SMEs in South Africa experiencing?	Baarsch et al., 2020; Chitonge, 2021; Scholes & Engelbrecht, 2021; Sautner et al., 2023	Interview questions 1 and 2	Coding and thematic analysis of interview findings
2. How are agro-processing SMEs innovating in response to the changing climate?	Su & Moaniba, 2017; Kahn, 2018; Alam et al., 2022; Matos et al., 2022 Durán-Sandoval et al., 2023	Interview questions 5 and 6	Coding and thematic analysis of interview findings
3. *What risks arising from climate change do agro-processing SMEs identify?*	Stolker et al., 2008; Crick, Eskander et al., 2018; Todaro et al., 2020; Simpson et al., 2021	Interview questions 3 and 5	Coding and thematic analysis of interview findings
4. What opportunities arising from climate change do agro-processing SMEs identify?	Saari et al., 2021; Phelan et al., 2022; Zurek et al., 2022; Hakovirta et al., 2023 Yang et al., 2023	Interview questions 4 and 5	Coding and thematic analysis of interview findings

Appendix C: Informed consent letter

Dear Sir / Madam,

I am a postgraduate student at the University of Pretoria's Gordon Institute of Business Science (GIBS), currently undertaking my research in partial fulfilment of a Master's degree in Business Administration (MBA). I am conducting research on climate adaptation and innovation in South African food and beverage manufacturing SMEs. I would like to understand how food and beverage SMEs are impacted by climate change and how they respond to those impacts.

This letter serves as confirmation of your consent to being interviewed for this research study. The interview is expected to last about 30 minutes. It will be conducted online, using the Zoom application. The interview will be recorded, as required by the University of Pretoria. Your participation is voluntary, and you can withdraw at any time without penalty. All information you provide will be reported without identifiers, i.e. your name and company name will not be mentioned in my research report.

If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher name: _____
Email: 20827840@mygibs.co.za
Phone: _____

Research supervisor name: _____
Email: _____
Phone: _____

Name of participant: _____
Signature of participant: _____
Date: _____

Signature of researcher: _____
Date: _____

Appendix D: Codebook

Note: Some open codes were clustered under multiple axial codes, but for simplicity, they are presented here under the most directly related axial code only.

Theme	Axial codes	Open codes
Input reliability challenges	Difficulty sourcing inputs	Agro-processing Climate vulnerability Drought resistant crops Sourcing unmodified inputs Unreliability input supply
	Declining quality	Effect on taste Poorer input quality Unpredictable weather Unsuitable climate
	Regional variations	Geographical diversification Eastern Cape Free State Gauteng KwaZulu-Natal Limpopo Mpumalanga Northern Cape North-West Western Cape
	Secondary concern	Climate change scepticism Limited future viability No current impact
Sustainable production	Research and development	Learning Product formulation Research Site analysis Skills development

	Product innovation	Creativity Innovation Invention Product variations
	Sustainable packaging	Enhancing shelf life Reusable packaging Recyclable packaging
Value chain management	Alternative farming methods	Greenhouses Hydroponics Organic farming Regenerative farming
	Appropriate technology	Artificial intelligence Cybersecurity Early warning systems Food science and technology Technology adoption Water conservation
	Climate change mitigation	Environmental impact Impact mitigation
	Value chain integration	Supporting local farmers Supply chain Understanding the value chain Vertical integration
Operational risk	Difficulty meeting demand	Future impacts Genetic modification Sourcing inputs internationally
	Compliance challenges	Food safety standards Licensing requirements
	Difficulty accessing finance	Access to finance Insurance costs Rising operational costs
Resource scarcity	Water insecurity	Access to water Altered rainfall patterns Conjunctive use

		Irrigation Rainwater harvesting Water conservation Water scarcity
	Energy insecurity	Energy efficiency Energy scarcity Renewable energy
	Food insecurity	Resilient food systems Perennial crops Seasonal demand variations
Stakeholder centricity	Indigenisation	Afrocentrism Embracing indigenous foods
	Raising climate awareness	Consumer education Creating awareness Increased awareness Preparedness
	Stakeholder management	Engagement Community support Empowering emerging farmers
	Health consciousness	Healthy diet trend Plant-based diet Rising demand for natural products Superfoods
	Strategic partnerships	Collaboration Consultation Opportunities for cofinancing Outsourcing Partnerships
	Support to SMEs	Government responsibility Government support Mentorship Coaching Support from industry bodies
Entrepreneurial bricolage	Positive climate effects	Increased input availability Alternative financing opportunities Carbon offset schemes

	Entrepreneurial behaviour	Branding Entrepreneurial thinking Improvisation Passion for one's product Understanding one's product
	Business expansion	Business growth Business strategy Business sustainability Enterprise development Opportunity to diversify Organic growth
	Differentiation	Customisation Market segmentation Personalisation Uniqueness

Appendix E: Ranking of business journals cited

Citation	Journal	AJG 2021 ranking	ABDC 2022 ranking
Sautner et al., 2023	Journal of Finance	4*	A*
Giglio et al., 2021	Journal of Financial Economics	4*	A*
Fisher, 2012	Entrepreneurship Theory and Practice	4	A*
Alam et al., 2022	Technological Forecasting and Social Change	3	A
Su & Moaniba, 2017			
Todaro et al., 2020			
van den Bergh, 2013			
Baarsch et al, 2020	World Development	3	A
Crick, Eskander et al., 2018			
Budden & Murray, 2022	MIT Sloan Review	3	A
Funder & Dupuy, 2022	Journal of Development Studies	3	A
Bacon et al., 2020	Journal of Business Research	3	A
Granstrand & Holgersson, 2020	Technovation	3	A
Matos et al., 2022			
Hakovirta et al., 2023	Business Strategy and the Environment	3	A
Pinkse & Kolk, 2010			
Moore, 1993	Harvard Business Review	3	A
Drucker, 2002			
Nyiwul, 2021	Journal of Cleaner Production	2	A
Phelan et al., 2022			
Kahn, 2018	Business Horizons	2	B
Bogodistov & Wohlgemuth, 2017	Journal of Risk Finance	1	B
Adhikari & Chalkasra, 2023	Journal of Sustainable Finance and Investment	1	-

Notes:

AJG: Academic Journal Guide, published by the Chartered Association of Business Schools

ABDC: Journal Quality List, published by the Australian Business Deans Council