An explorative case study of the adaptation process used by an East Coast hill country sheep and beef farmer in New Zealand to cope with climate change

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Abstract

North Island East Coast hill country sheep and beef farmers in New Zealand are expected to face increased climate variability due to climate change. Over time the frequency, severity and intensity of adverse weather events such as ex-tropical cyclones, heavy rainfall events and drought will exacerbate resulting in increased uncertainty for farmers. As such, due to the changing climate in a farmer's operating environment the development of a farmer's adaptive capacity and their ability to manage and adapt to the impacts of climate change becomes important for sustaining a viable and resilient farming system. However, little is known about how a farmer with high adaptive capacity identifies change in their operating environment and the process they use to adapt their farming system to cope with such impacts.

As such, to determine the main attributes associated with a high level of adaptive capacity and provide an understanding of a farmers adaptation process in relation to climate change, an extensive literature review was undertaken. This review helped to develop a conceptual framework that was used to guide this study. The main attributes associated with a high level of adaptive capacity that were identified are an internal locus of control, sense-making capability, capacity to learn to live with change and uncertainty, strategic thinking and planning capability, and high self-efficacy.

A single explorative case study of an East Coast hill country sheep and beef farmer exhibiting a high level of adaptive capacity was used to investigate the adaptation process. The process used by the case farmer can be usefully separated into three main stages: 1) a sense-making stage where he; a) scans the operating environment for cues that indicate a change, b) identifies a change in the operating environment in relation to climate change, and c) assesses the nature and the impact of the change on the farm system, and 2) a SWOT analysis and strategy formulation stage where he; a) assesses the opportunities and threats that flow from the identified impacts of the change, b) undertakes an internal analysis and capability assessment to determine if the current suite of strategies can cope with the threats and opportunities, and d) on the basis of the previous step, if required, he formulates a new strategy (or strategies) to adapt to the impacts of the change, and 3) the implementation and control stage where he; a) implements the new strategy and b) monitors and evaluates the implementation of the new strategy. The farmer's sense-making efforts and analysis of the farm system highlights the importance of gaining a complete understanding of the situation of change and its impact before acting upon it through a decision-making process. Based on such the SWOT analysis, it highlighted that the farmer's buffer capacity to manage and cope with such impacts of climate change may be adequate in relation to the level of change identified in the operating environment. As such the case farmer identified that his current suite of strategies and associated tactics have the capability of coping with the threats and opportunities identified in relation to climate change on the East Coast. Such study also highlights that the formulation of new strategies is not always necessary and therefore prompts the continuation of making sense of change in his operating environment until he identifies that his suite of strategies are not capable of coping with an increased level of change.

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Chapter One

1. Thesis introduction

In this first chapter, details on the background and the purpose of this research are provided. Section 1.1., explores the research background, providing details of the New Zealand sheep and beef sector and the importance of hill country sheep and beef farming to the New Zealand economy. The section goes on to explore the shocks and long-term stressors affecting the sector, with climate change being identified as a long-term stressor effecting New Zealand hill country farming but more specifically effecting the environment on the East Coast including Gisborne, Hawkes Bay, and Wairarapa regions, of the North Island, New Zealand. The East Coast's regions are explored in some detail and reference to historical adverse weather events and current research predictions of changes that may occur in the future in relation to climate change are provided. The section goes on to explore resilience and the three elements: buffer capacity, adaptive capacity, and transformability, drawing from the resilience and social-ecological literature. Emphasis is placed on adaptive capacity, as the level of change in the environment requires farmers to adapt to cope with a changing environment to sustain production in the industry. Following this section, Section 1.2., describes the problem statement, followed by Section 1.3., which describes the research aim and Section 1.4., which describes the research question and lastly Section 1.5., sets out the research objectives.

1.1. Background

The New Zealand sheep and beef sector produces around 362,000 tonnes of lamb, 92,000 tonnes of mutton, 712,000 tonnes of beef, and 137,000 tonnes of wool (greasy) (Beef and Lamb New Zealand, 2021b). Exports free on board from the sector were valued at $3,331 million for lamb, $643 million for mutton, and $3,811 million for beef and veal in the year ended June 2020 (Beef and Lamb New Zealand, 2021b). Wool including all by-products represent 0.9% ($530.0 million) of export earnings from the sector (Beef and Lamb New Zealand, 2021b). New Zealand exports between 95% and 99% of the beef and lamb cuts produced respectively to its global markets (Beef and Lamb New Zealand, 2020). Major markets include Northern Asia and the European Union, followed closely by North America and the Middle East (Beef and Lamb New Zealand, 2021b). The sheep and beef industry in New Zealand contributes approximately $5.0 billion to national GDP (gross domestic product), with a further $3.6 billion of added value. This contribution to national GDP makes the sector of great importance for the economic growth of regional centres and the New Zealand economy (Beef and Lamb New Zealand, 2018, 2021b).

Although the sector has seen a significant decline in sheep numbers (58 million sheep in 1990-91 to 27 million in 2019-20) (Beef and Lamb New Zealand, 2020), due to land use change to dairy on the better

country and forestry on the poorer country, lamb production has increased significantly. Increases have been observed in lambing performance (102 lambs/100 ewes in 1990-91 to 129 lambs/100 ewes in 2019-20) and heavier finishing lamb weights (13.9kg/head in 1990-91 to 19.0kg/head in 2019-21) (Beef and Lamb New Zealand, 2021a). Beef production numbers have reduced (4.6 million in 1990-91 to 3.7 million in 2019-20), although not as significantly in comparison to sheep (Beef and Lamb New Zealand, 2020). Despite this reduction, steer weights for finishing have increased (297kg/head in 1990-91 to 312kg/head in 2019-20) (Beef and Lamb New Zealand, 2021a). The productivity increases observed from sheep and beef farming are a demonstration of increased efficiency and have incrementally increased the profitability of sheep and beef farms across New Zealand since 1990-91 (Beef and Lamb New Zealand, 2020). Farmers have put significant emphasis on improving breeding genetics for meat production efficiency, and advancements in land and animal management practices, without needing to increase stock intensity to do so (Beef and Lamb New Zealand, 2020).

New Zealand hill county farming is an important contributor to the New Zealand sheep and beef sector comprising around 50% of the farms in the sector (Beef and Lamb New Zealand, 2020). Currently there are around 4595 hill country farms in New Zealand, many of which are extensive and low input farm systems, that comprise a mixture of flat, rolling, and steep topography. Hill country farm systems are highly sensitive to environmental conditions due to their particularly low inputs of fertiliser and purchased feed which impacts on their profitability and sustainability (Beef and Lamb New Zealand, 2020). Hill country farms produce lambs and cattle either prime[1] for slaughter or sold as store animals[2]. They are also a key supplier of young livestock for finishing farms and hold historical significance to New Zealand's pioneering farming days (Beef and Lamb New Zealand, 2020). Hill country farms have seen a significant increase in profitability (84% increase in profit per hectare) since 1990-91. These farms also hold approximately 12% of New Zealand's native vegetation cover, and a large proportion of farm forestry and Manuka for apiculture (Beef and Lamb New Zealand, 2020).

Although the hill country plays an important role in the New Zealand economy, there is growing concern that these farms are facing an increasingly turbulent internal and external operating environments (Chappell, 2019; Gray et al., 2011). Such turbulence exposes hill country farmers to a range of changes that have been classified as shocks, and long-term stressors (Darnhofer, 2021; Folke, 2006; Nicolas-Davies et al., 2021; Meuwissen et al., 2019; Spiegel et al., 2021). Shocks are defined as reversible or irreversible effects on the farming system which may only be temporary, however, their impacts are dependent on a systems resilience (Meuwissen et al., 2019, p. 4). In contrast, stressors are defined as gradual long-term changes that influence a

[1] Prime – sold direct to meat works or abattoir for slaughter.
[2] Store – sold through private agent or auction at the saleyards for finishing farms.

systems environment (Meuwissen et al., 2019). Long term stressors are likely to increase the temporal vulnerability of a farming system, therefore leading to tipping points where critical thresholds are crossed (Walker et al., 2004). Examples of long-term stressors affecting New Zealand hill country farmers are climate change, changing consumer preferences, increasing environmental regulations, governmental support for agriculture, export regulations and tariffs, market power within value chain systems, interactions between farmers and stakeholders, soil erosion, loss of ecosystem habitats and settlements of invasive pest species on farm (Bertolozzi-Caredio et al., 2021; Hogan et al., 2011; Meuwissen et al., 2019; Nicholas-Davies et al. 2021).

In terms of stressors, climate change has been identified as an important form of gradual change affecting New Zealand hill country farms (Chappell, 2019; Hawkes Bay Regional Council, 2021; Ministry of Environment, 2017; National Institute of Water and Atmospheric Research, 2020a). Climate change is likely to impose both positive and negative effects on hill country farming. This is due to ongoing future changes to the climate at the farm level which is potentially of high risk to the sector (Lieffering et al., 2012). Although seasonal variations in climate occur in the hill country environment, the climate is greatly modified by ocean currents and hilly topography. Therefore, latitude, topography, altitude, aspect, proximity to the coast, and season influence pasture production and it is directly related to regulating temperature and soil moisture availability for pasture growth. As climate change influences pasture production on farm, this creates an accumulative effect for other aspects of the farming system such as profitability and efficiency (Lieffering et al., 2012; Ministry for Environment, 2017; National Institute of Water and Atmospheric Research, 2020). Indications are suggesting that climate change is shifting seasonal variations in hill country farms across New Zealand and exposing farmers to an increasing level of change. These changes in the environment expose farmers to greater risk and increase a farm systems vulnerability (Ministry for Environment, 2017; National Institute of Water and Atmospheric Research, 2020a).

The hill country farms on the East Coast of the North Island have been identified as particularly vulnerable to climate change (Chappell, 2019a). The East Coast includes the Gisborne, Hawkes Bay, and Wairarapa regions which have a history of extreme weather events. Over the last decade, these regions have experienced both droughts and intense rainfall events (Chappell, 2019a). Climate change is expected to increase the level of climatic variability on the East Coast (Mullan et al., 2008). In the Gisborne region, dominating northerly and south-easterly winds lead to variable rainfall distribution as shown in Figure 1 (Chappell, 2019a). Annual rainfall in the Hawkes Bay region varies to a similar degree to the Gisborne Region (Figure 1) (Chappell, 2019b). Meteorological systems bringing rain to the East Coast are irregular, causing high rainfall variability both spatially and temporally (Figure 1). Although seasonal influences on rainfall distribution are quite well defined, the intensity, frequency, duration, and droplet size are highly variable (Chappell, 2019b). Thus, the advent of high intensity rainfall events is often caused by tropical cyclones that move southwest and bring intense rainfall to the East Coast (National Institute of Water and

Atmospheric Research, 2020a). The East Coast is susceptible to these rainfall events because of mountainous terrain and orographic influences (Chappell, 2019a).

Figure 1 Gisborne (left) and Hawkes Bay (right) Regional Median Annual Total Rainfall (mm) (Chappell, 2019a,b).

Adverse weather events are highly unpredictable and expose farmers to uncertainty and risk (Chappell, 2019a; White et al., 2009). In March 1988, the ex-tropical cyclone Bola produced the highest recorded rainfall total for a single storm event within the North Island (Chappell, 2019a). Many hill country farms in the Gisborne region received over 800mm of rain over a four-day period (Chappell, 2019a). Hawkes Bay and Wairoa also experienced significant rainfall. This resulted in significant flooding, river erosion, and landslides, where some farmers lost 30% of their total grazing area (Chappell, 2019b). There was also loss of stock and infrastructure (e.g., tracks, fencing and water supplies, buildings, yards) and flooding that limited farmers' ability to manage their properties effectively (Chappell, 2019a). Another notable event was a deep low-pressure system in September 1988 that brought torrential rain and high winds and caused severe flooding and damage to the regions. It was said that some farmers lost 10% of lambs during this storm because it occurred during lambing (Chappell, 2019a). More recent rainfall events that have occurred on the East Coast of the North Island have resulted in State of Emergencies (SOE) being declared throughout the East Coast by the National Emergency Management Agency (Civil Defence) due to flooding and slips. In the previous three years, the Hawkes Bay Region declared a SOE in November 2020, followed by Gisborne in November 2021 and March 2022. Heavy rainfall impeded on the East Coast causing widespread flooding, slips and damage to farmland and road infrastructure (National Emergency Management Agency, 2022).

Although the East Coast experiences adverse weather events e.g., heavy rainfall and ex-tropical cyclones, it also experiences drought. Droughts are a feature of hill country farming on the East Coast, and over the last two decades the frequency and incidence of drought has increased (Chappell, 2019a,b; Hawkes Bay Regional Council, 2021). Drought on the East Coast is dependant and influenced by two weather systems known as El Niño and La Niña (National Institute of Water and Atmospheric Research, 2020b). During an El Niño year, lower seasonal temperatures are present across New Zealand and drier than normal conditions occur on the East Coast. In comparison during a La Niña year, higher than normal temperatures (especially during summer) are experienced across New Zealand and wetter conditions occur in the north and east of the North Island. This suggests that during El Niño conditions, there is likely to be insufficient rainfall causing dry spells which can develop into a drought, with depleting soil moisture levels and seriously limiting plant growth (Chappell, 2019a,b; National Institute of Water and Atmospheric Research, 2020b). El Niño is likely to remain the dominant mode of natural climate variability within the 21st century, therefore indicating increased rainfall variability and greater uncertainty in rainfall occurrence (National Institute of Water and Atmospheric Research, 2020b). Recently the Hawkes Bay experienced a severed drought in 2020 (Hawkes Bay Regional Council. 2021) and all regions on the East Coast experienced a severe drought in 2017 (Chappell, 2019a). In 2012-2013, a drought occurred across the entire North Island, including the East Coast and it was identified as one of the most severe droughts on record (Chappell, 2019a). During this drought, the East Coast suffered from extreme soil moisture deficit, which caused pasture growth to cease, and therefore farmers had to sell stock and buy in supplementary feed. This drought caused an estimated economic loss of $1.6 billion (Chappell, 2019a).

Looking to the future, recent climate change research suggests that there will be an increase in the intensity, severity, and frequency of adverse weather events such as intense rainfall events and droughts on the East Coast because of climate change (Chappell, 2019; Ministry of Environment, 2017; National Institute of Water and Atmospheric Research, 2020a). This is likely to occur in the coastal, inland, and hill country areas of the East Coast. It is projected that there will be an increase in rainfall over or to the west of the mountainous parts of all East Coast regions during winter, and for northern Gisborne during autumn. An increase of 5-15% in annual rainfall is projected for high elevation areas in the westernmost area of Hawke's Bay during winter. Additionally, small increases (0-5%) in rainfall are projected for some coastal parts of Hawke's Bay during summer and autumn (National Institute of Water and Atmospheric Research, 2020a). Research suggests that the East Coast may experience drier summer conditions and increased severity and frequency of drought due to infrequent rainfall during the summer by 2080 (Mullan et al., 2008). For example, in a 'low–medium' climate change scenario, Gisborne and Hawkes Bay could experience a 1-in-20-year drought event every 3 to 5 years by 2080. There is also the possibility of droughts occurring in spring and autumn, with drought risk increasing resulting in the early onset of drought by a month and the possibility of back-to-back droughts (Mullan et al., 2008; National Institute of Water and Atmospheric Research, 2020b). Higher evapotranspiration rates are expected to occur in all seasons (mid-spring to early

autumn) leading to soil moisture deficits and low pasture growth (Ministry of Environment, 2017; National Institute of Water and Atmospheric Research, 2020b), which will reduce pasture quality and quantity (Avery et al., 2008). When pasture quantity is low, there is will be a need to alter on-farm stocking rates and potentially sell capital stock or use farm produced supplementary feed or purchase feed to manage these conditions (Gray et al., 2011).

If the above projections are correct, East Coast farmers will face increased frequency of climate extremes, greater weather variability, and changes to baseline rainfall and temperatures (Kenny & O'Brien, 2007; Ministry of Environment, 2017). Given this outlook, the future of hill country sheep and beef farming on the East Coast will be highly dependent on farmers' ability to build resilience and to adapt their farming system to cope with change. However, there are concerns about how hill county farmers on the East Coast will build resilience in the face of this changing environment. If these farmers are unable to build their resilience and therefore adapt to such changes, sheep and beef production may decline and this will have negative impacts on export supply chains, employment in the sector and rural communities in these regions (Beef and Lamb New Zealand, 2021a).

Resilience is an important attribute of farm systems which face uncertainty as it allows them to prepare, cope and persist in the face of shocks and long-term stressors in the environment (Darnhofer, 2021; Folke, 2016). Resilience comprises of three key attributes: buffer capacity, adaptive capacity, and transformability (Figure 2) (Shadbolt et al., 2013; Walker et al. 2004). In the farming context, a key attribute of resilience is buffer capacity (Walker et al., 2004). It is the ability to bounce back in response to uncertainty in a relatively stable environment, therefore allowing a system to persist and cope with normal variation in the environment (Folke., 2006; Shadbolt et al., 2013. p.3; Walker et al., 2004).

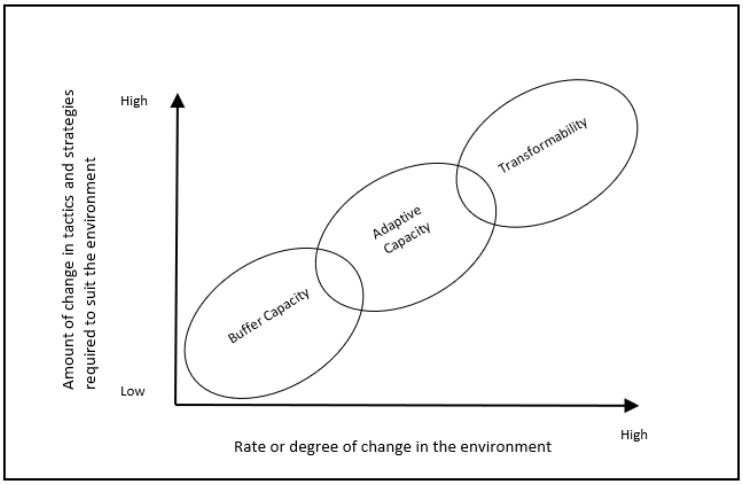

Figure 2 Illustration of the Continuum of change, buffer capacity, adaptive capacity, and transformability (Shadbolt et al., 2013).

In a relatively stable environment, farmers develop a suite of strategies and associated tactics to cope with the level of uncertainty in the environment (Shadbolt et al., 2013). How well they do this, will depend upon

the suite of strategies and tactics they have and the degree of uncertainty in the environment (Walker et al., 2004). Importantly, uncertainty is not just about downside risk, it also provides opportunities that farmers can exploit (upside risk) and as such, farmers have contingencies derived from their suite of strategies and tactics that they use to mitigate the impact of downside risks and take advantage of upside risks (Shadbolt et al., 2011). Buffer capacity is important for coping with uncertainty in a relatively stable environment, but in a changing environment, adaptive capacity, the second attribute of resilience (Figure 2) becomes important and as such is a key element of resilient farming systems (Darnhofer, 2021; Gray et al., 2011; Nicholas-Davies et al., 2021; Shadbolt et al., 2013).

Adaptive capacity is defined as "the capacity of actors in a system to influence resilience" (Walker et al. 2004, p.1) and is often associated with changes that are occurring in the underlying environment, such as climate change (Folke, 2006). Adaptive capacity is mainly associated with an individual's own attributes (Walker et al., 2004), whereby farmers are the key decision makers in a farming system and hence play a critical role in the adapting their system to cope with the impacts of change (Hyland et al., 2016). Adaptive capacity requires two key capabilities. Firstly, farmers need to be aware of change in order to identify that a change in the environment is occurring (Hyland et al., 2016) and, secondly the ability to change one's suite of strategies and associated tactics to cope with that change. The latter may result in a change in the composition of inputs, production, and risk management in response to the change in the environment (Darnhofer., 2021; Folke., 2006; Meuiwissen et al., 2019; Speigel et al., 2021). Identifying when change in the environment has occurred, and the true nature of that change is important. If the environment is stable, this would indicate that adaptation is not required, and a farmer can focus on their buffer capacity. Once change has been identified, the farmer must identify suitable strategies and associated tactics that will either, take advantage of opportunities, or mitigate the impacts of the change to help their farming system cope with a changing environment (Hyland et al., 2016; Roesch-McNally et al., 2017).

The adaptive capacity of an individual is expressed as a process of deliberate change in anticipation of, or in reaction to external stimuli and stressors (Folke, 2006). Adaptive capacity can cope with changes in the environment up to a point, however, a breaking point can occur when disturbances impose on a system beyond what it can physically, socially, and financially tolerate. At this point, the current system is no longer tenable within the new environment and to survive the system must transform (Meuiwissen et al., 2019; Nicholas-Davies et al., 2021; Speigel et al., 2021; Walker et al., 2004). As such, transformability, the third attribute of resilience (Figure 2) becomes important (Walker et al., 2004). Transformability has also been described by Darnhofer et al., (2008, p. 1), as "the ability of a farm owner or manager to find new ways of arranging resources when conditions make the current system untenable".

Although each attribute of resilience is of importance, their relevance depends on the degree or level of change that is occurring in the environment (Figure 2). Buffer capacity is important within a stable environment, whereas adaptive capacity becomes important if the environment is changing and

transformability is important when the degree of change in the environment is so great that existing farm systems are untenable (Figure 2) (Walker et al., 2004). Importantly, after a period of change where a farmer has adapted and introduced new strategies to cope with this, buffer capacity then becomes the focus until further change occurs in the environment (Shadbolt et al., 2013). However, farmers cope differently with changes in the environment. Their response is dependent on the level of change, their awareness of the change, their perceptions of the risks associated with the change and their ability to respond (Gray et al., 2011; Shadbolt et al., 2013; White et al., 2009). When farmers are exposed to varying levels of change (e.g., climate change, leading to increased frequency of drought or climate extremes) in the environment, they are required to make significant changes to their strategies and associated tactics they utilise to cope, adapt and to mitigate the effects of such changes (Darnhofer, 2021; Shadbolt et al., 2013).

New Zealand hill country farmers are taking actions to reduce the impacts of climate change and adapt to it through tactical, adaptative and transformative approaches (Lieffering et al., 2012). Given the geographical size of New Zealand and its greenhouse gas (GHG) emissions, changes made by farmers to reduce carbon emissions will have very little impact on climate change. Research suggests that the impacts of climate change will increase over time unless greenhouse gas levels are reduced to suitable levels (Lieffering et el., 2012; National Institute of Water and Atmospheric Research, 2020a; Ministry for Environment, 2017). Although it is important that New Zealand hill country farmers focus on adapting to changes and build their adaptive capacity, it is also important for them to implement mitigation strategies that aim to reduce greenhouse gas emissions (Ministry of Environment, 2017). This is due to increasing pressure from the New Zealand Government where legislation has been targeted at the New Zealand agricultural sector. This sector plays a vital role to meeting reduction targets as a part of international commitments on global climate change and the Zero Carbon Act. A newly implemented programme known as “He Waka Eke Noa - The Primary Sector Climate Action Partnership” has been developed as a practical framework to achieve such reductions. This programme involves measuring emissions and sequestration on farm. It encompasses a farm-level pricing system that will be developed by 2025. It will incentivise farmers who make changes to reduce on-farm emissions (Beef and Lamb New Zealand, 2021c). Other legislation such as the National Environmental Standards for Freshwater Regulations 2020 may also play a part in farmers adaptations and mitigation strategies, particularly around fertiliser inputs, stock exclusion from waterways, and intensive winter grazing (New Zealand Government, 2020).

Research suggests that the environment on the East Coast is experiencing change due to climate change and that the impacts of climate change are expected to exacerbate by 2080 depending on the prediction scenarios (Ministry of Environment, 2017; Mullan et al., 2008; National Institute of Water and Atmospheric Research, 2020a). As such the adaptive capacity of East Coast hill country farmers is important in ensuring they continue to farm to maintain their livelihood. It may be that by the end of the century, conditions could be such that farmers will be forced to transform their farming system. However, the focus of this study is on adaptive capacity and the continued operation of hill country sheep and beef farms on the East Coast.

Despite the importance of climate change, much of the research effort in New Zealand has been in relation to reducing greenhouse gases rather than the adaptive capacity of farmers. As such, little is known about the adaptive capacity of New Zealand farmers and limited research has been undertaken into the adaptive capacity of East Coast Hill country farmers in relation to climate change. There is very limited understanding about the process used by farmers to identify change in the environment or the process they use to adapt their farming system to cope with such change. Identifying, resilient farmers that are recognised as having high adaptive capacity and describing how they are adapting there farming systems to cope with climate change would provide valuable knowledge for the sheep and beef sector going forward. Such a study would provide insights into the processes and the strategies that other hill country sheep and beef farmers on the East Coast could use to better cope with climate change.

1.2. Problem statement

Hill country sheep and beef farmers on the East Coast of the North Island in New Zealand are facing ongoing changes to their operating environment due to climate change. Climate change is increasing the frequency, severity and intensity of adverse weather events such as tropical cyclones, heavy rainfall events and drought due to increased variability of rainfall and warmer temperatures. Research suggests such changes will exacerbate over time causing increased climatic variability until global greenhouse gas levels are reduced to suitable levels. East Coast hill country farmers will still be required to adopt strategies that reduce and mitigate greenhouse gases due to legislation imposed on the New Zealand agricultural sector. However, given that changes made by NZ farmers will have little impact on climate change, hill country farmers on the East Coast will need to focus on adapting to changes in the climate and the development of their adaptive capacity. Despite its importance, little is known about the process a farmer with high adaptive capacity uses to identify change in the environment in relation to climate change and then adapt their farming system to cope with this.

1.3. Research aim

The aim of this study is to understand the processes a farmer with high adaptive capacity uses to to identify change in the environment in relation to climate change and then adapt their farming system to cope with this, so that this information can be used to help other hill country farmers on the East Coast adapt to climate change.

1.4. Research question

How does a farmer with high adaptive capacity identify change in the environment in relation to climate change and then adapt their farm system to cope with this?

1.5. Research objectives

In order to answer the research question, the following objectives are addressed:

- Review the literature to develop a conceptual framework of the attributes of a highly resilient farmer with high adaptive capacity.
- Review the literature to develop a conceptual framework of the process farmers with high adaptive capacity would use to a) identify when their environment is changing and the nature of that change and b) to develop a suite of strategies and associated tactics to cope with that change.
- Identify an East Coast hill country sheep and beef farmer with a high level of adaptive capacity.
- Describe the process an East Coast hill country sheep and beef farmer with high adaptive capacity uses to identify changes in the environment in relation to climate change.
- Describe the process an East Coast hill country sheep and beef farmer with high adaptive capacity uses to adapt their farming system to cope with this change.

Chapter Two

2. Literature Review

2.1. Introduction

The aim of this chapter is to review the literature that is relevant to the question in Section 1.4. As such, the literature will be drawn from a wide range of disciplines including ecology, socio-ecological systems, agricultural systems, and farm management. The chapter is organised into the following sections. Section 2.2., will review the literature on resilience, with a focus on adaptive capacity. Section 2.3., will review the literature on the farmer attributes that are associated with a high level of adaptive capacity. Section 2.4 will review the literature on farmers' operating environment and their vulnerability to climate change. Section 2.5., will review the literature on the adaptation process, this includes the processes that a farmer with a high level of adaptive capacity uses to a) identify a change in their operating environment, b) determine the nature and impact of that change on their farm system and then c) formulates a suite of strategies to cope with and adapt to the impacts of climate change. In the final section (2.6), the literature will be summarised to provide a conceptual framework that will guide the study.

2.2. Resilience

In this study, the aim is to identify a 'resilient' case farmer with high adaptive capacity. To do this it is important to provide background literature on the concept of resilience. Section 2.2.1., reviews the literature on the concept of resilience, setting out the fundamentals of resilience among the relevant disciplines. Section 2.2.2., reviews the literature to define resilience drawing on relevant disciplines. Finally, Section 2.2.3., reviews the three elements of resilience; buffer capacity, adaptive capacity, and transformability to provide a comparison of each element, with adaptive capacity being the key element being researched in this study. Literature has been drawn from the disciplines of ecology, socio-ecological systems, psychology, organisational business management, and farm management to provide a good understanding of resilience and adaptive capacity.

2.2.1. The fundamentals of resilience

The concept of resilience was first conceptualised by Holling (1973) within ecology, whereby the initial discovery of resilience was in relation to the environment and its association with an ecosystems ability to absorb change (Holling, 1973). The concept of resilience has since evolved and is widely applied to many disciplines such as psychology, organisational business management, and farm management. Firstly, in psychology, resilience has often been used to describe the coping endurance of individuals when facing life

difficulties such as internal stress and discomfort as well as pressure individual's experience in their lives (Fletcher & Sarkar, 2013).

Secondly, in organisational business management, resilience theory encompasses resistance capacity to cope with unfavourable conditions such as disturbances and changes that arise in the external environment. It conceptualises this ability as one that preserves the businesses position and capabilities to benefit from these unfavourable conditions (Kantur & Iseri-Say, 2015). Resilience in this discipline is developed and managed through "a set of specific organizational capabilities, routines, practices and processes by which a firm conceptually orientates itself, acts to move forward, and creates a setting of diversity and adjustable integration" (Lengnick-Hall et al., 2011, p. 245). Individuals have a wide range of cognitive, behavioural, and contextual capabilities and routines which positively contribute to organizational resilience. Under the organisational discipline, resilience is enhanced through leadership, awareness, understanding the operating environment, the ability to manage vulnerabilities via adapting to change, high quality human capital, and the ability to create financial viability (Ho et al., 2014; Lee et al., 2013). General resilience theory emphasizes change, uncertainty, and the capacity of a system to adapt (Holling et al., 2002). It also emphasizes that for social-ecological systems, the individual, organisation, community, and societal levels are embedded within the concept of resilience (Folke, 2006). However, at the community organisational level, resilience theory is used to understand how communities respond to unexpected shocks, such as natural disasters, Acts of God, and terrorism (Folke, 2006).

Drawing on the work in ecology (Holling, 1973; Holling et al., 2002), the farm management literature has viewed resilience as the capacity of a farm system to "bouncing-back" after a disturbance (Folke, 2006) and more importantly to cope with changes in the environment (Darnhofer, 2010; Crawford et al., 2007; Darnhofer et al., 2010; Kaine & Tozer, 2005; Shadbolt et al., 2011). For example, e.g., how a farmer copes with the increased frequency of drought or climate extremes that impose threats to his/her farming system. Some studies have investigated how resilience is built through the interactions and collaborations between a range of stakeholders including farmers, scientists, researchers, agricultural extension agents and members of society (Le Goff et al., 2022; White et al., 2009). Much of the resilience research on hill country sheep and beef farm businesses in New Zealand has been undertaken to understand and address the issue of dryland farming, adverse weather events, and drought environments (Avery et al., 2008; Gray et al., 2011; White et al., 2009). Some research has also focused on assessing resilience and the capacities required to mitigate the impacts associated with disturbance within their farming systems (Nicholas-Davies et al., 2021). There is limited empirical research undertaken on resilience at the farm level and more importantly the individual farmer level (Crawford et al., 2007; Darnhofer et al., 2010; Darnhofer et al., 2012 and Shadbolt et al., 2011). There is limited research into the adaptation process used by farmers to cope with a change in the environment.

Darnhofer et al. (2012) has previously argued that the reasons for limited resilience research within farm management is due to the discipline focusing on traditional methods of management. The traditional approach focuses on the development and innovation of technologies and management practices that are designed to increase productivity and profitability in a stable environment, rather than to adapt to disturbance. This ideology collides with the concept of resilience. Crawford et al. (2007) suggests that farm management practices do not consider the effects or impacts of long-term risk and uncertainty on farm sustainability and stability. The concepts of risk and uncertainty are important aspects of resilience. Crawford et al. (2007) and Hyland et al. (2016) have suggested that to build resilience, a farm manager or owner must be able to manage the risk and uncertainty that their farm system is exposed to. Therefore, a farmer must have a sense of self-identity, and be aware of any environmental changes or threats that affect their farming system. They must also have a good perception of the risks facing their farming system to manage or cope with that uncertainty associated in the environment (Hyland et al., 2016). Nevertheless, not much is known about farmer identity and the characteristics of a resilient farmer, or the drivers and motives that influence a farmer's ability to identify change and how they perceive risk in their farm environment.

2.2.2. Defining resilience

There are a variety of definitions used to define resilience across different disciplines. They all draw upon the concepts developed in ecology and social-ecological systems (Darnhofer, 2010; Folke, 2006; Shadbolt et al., 2011; Walker et al., 2004). The definition of resilience is dependent on the discipline, the level of analysis and application to the landscape, farm, and individual level (Shadbolt et al., 2011; Walker et al., 2004). A common definition by Walker et al. (2004) defined resilience as "the capacity of a system to absorb disturbance and re-organise while undergoing change as to still retain essentially the same function, structure, identify and feedbacks" (p. 2). In the farm management discipline, resilience has been defined for a dairy farm business as "the capacity of a farming system to not only adapt to change in the environment, but also take advantage of opportunities created by a disturbance while maintaining productive capacity in the face of variability in production, financial and market related issues" (Shadbolt et al., 2011, p.8). Other farm management authors have used the term "sustainability" to define resilience (Conway, 1985; Hansen & Jones, 1996; Kaine & Tozer, 2005; Marten, 1988). However, resilience has been identified as an influential factor and a precursor to achieve sustainability in a farm system (Parsonson-Ensor & Saunders, 2011).

In the discipline of psychology, individual resilience is defined as "the capacity of individuals to cope successfully with significant change, adversity or risk" (Lee & Cranford, 2008, p. 21). Connor and Davidson, (2003), also defined resilience as ''the personal qualities that enables one to thrive in the face of adversity'' (p. 76). Both definitions give rise to coping capacity or the capacity to thrive when undergoing change, adversity, or risk. However, there are differences between each definition when contrasting the definitive perspectives. Although Lee and Cranford (2008) highlight one's abilities and therefore capacity, Connor and Davidson (2003) acknowledges the individual and their personal qualities. These qualities are cognitive,

behavioural, and contextual capabilities that are expressed by individuals among organisational disciplines (Ho et al., 2014; Lee et al., 2013). The capabilities and qualities described by Ho et al. (2014) and Lee et al. (2013) are embedded in Bonanno's (2004) definition of psychological resilience as "the ability of adults in otherwise normal circumstances who are exposed to an isolated and potentially highly disruptive event (death or a violent or life-threatening situation) to maintain relatively stable, healthy levels of psychological and physical functioning, as well as the capacity for generative experiences and positive emotions" (p.20-21).

Individual resilience in psychology is defined by Masten, Best, and Garmezy (1990, p. 426) as "the process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances". Luthar et al. (2000) also defined it as "a dynamic process encompassing positive adaptation within the context of significant adversity" (p. 543). This approach employs a threshold-dependent definition that is closely aligned with risk. These definitions suggest that resilience is a process rather than an attribute of an individual. This is further evident in Greenhill et al.'s (2009) study on the resilience of Australian farming families which defines the individual resilience of farmers as "a process where an individual displays positive adjustment such as psychological wellbeing or absence of psychological distress despite experiencing adversity like severe drought" (p. 318). Greenhill et al.'s (2019) definition argues that resilience is more a process that is developed, and it promotes resilience in rural communities to reduce stress and the effect it has on a farmer's mental well-being.

Many of the resilience definitions described above share some similarities and have their obvious differences. However, a common aspect among these definitions of resilience is individuals alike have meaning and in the face of adversity or external events they adjust or simply adapt to fulfil meaningfulness, purpose or positive well-being (Bonanno, 2004; Connor & Davidson, 2003; Masten, Best, & Garmezy, 1990; Shadbolt et al., 2011; Walker et al., 2004). In addition, some differences among definitions suggest contrasting views of the external events that occur. For example, psychological scholars such as Lee and Cranford (2008), and Connor and Davidson (2003) emphasise coping capacity and personal qualities (capabilities and abilities) to mitigate, reduce and cope through periods of change, such as disturbances and risks occurring in the external environment, while other definitions (Greenhill et al., 2009; Shadbolt et al., 2011; Walker et al., 2004) draw on resilience as a response to threats, or to take advantage of new ideas or opportunities that may arise in the environment.

2.2.3. The three elements of resilience

Resilient systems are considered to have three main elements; buffer capacity, adaptive capacity, and transformability (Walker et al., 2004). Each element represents a system's ability to respond to differing degrees of change within the underlying environment (Walker et al., 2004). Buffer capacity is considered a critical element of resilient systems and is defined as the capacity to absorb disturbance, and to bounce back to its original state (Walker et al., 2004). Buffer capacity allows a system to persist during change (Conway,

1991; Folke, 2006; Walker et al., 2004, Darnhofer., 2021). Although buffer capacity is a critical element of resilience and relates to a systems robustness, the opportunities that arise from disturbance and the capacity of an organisation to adapt to change is just as important (Folke, 2006).

The second element of resilience is adaptive capacity. Adaptive capacity has been identified as a key element of resilience in farm systems and is a major element of change (Darnhofer, 2021; Gray et al., 2011; Nicholas-Davies et al., 2021; Shadbolt et al., 2013). Adaptive capacity is associated with changes that are occurring in the underlying environment. It is typically associated with adaptability which is the capacity to change composition of inputs, production, and risk management in response to change (Darnhofer., 2021; Folke., 2006; Folke., 2016; Meuiwissen et al., 2019; Speigel et al., 2021). Darnhofer et al. (2010) described this as farmers having the strategies to persist and maintain through shocks and adapt or adopt new states when they are needed. However, Crawford et al. (2007) described adaptive capacity as the degree to which a farm system can respond to change (e.g., adapt to change). Crawford et al. (2007) and Conway (1993), argued that adaptive capacity is more concerned with major disturbances which are considered rare and tend to occur due to major changes within the environment. Adaptive capacity is based around the key coping mechanisms required where rapid and unforeseeable change occurs (Darnhofer et al., 2010; Kaine & Tozer 2005). These therefore strengthen the farmer's ability to respond to change and to sustain long-term survival and stability (Darnhofer et al., 2010; Kaine & Tozer 2005). Adaptive capacity also involves changes in the structure of the farm system, so that the system adapts to change imposed by the environment without altering its key functions (White et al., 2009).

As with buffer capacity, adaptive capacity can work up to a point. As disturbances continue to impose on a system beyond what it can physically, socially, and financially tolerate, transformation of the system will be the only viable option (Walker et al., 2004). Transformability is the third element of resilience (Walker et al., 2004). It occurs where changes or disturbances in the environment are so great that the current farm system is untenable or unviable and requires transformation to survive (Meuiwissen et al., 2019; Nicholas-Davies et al., 2021; Speigel et al., 2021). Transformability has also been described in farm management as the ability of a manager to find new ways of arranging resources when conditions make the current systems untenable (Darnhofer et al., 2008). Although farm systems rarely get to a point where transformability is required, transformability implies a change (transformative change) in the purpose or aim of a system (Darnhofer, 2021). This section has explored the concept of resilience including the focus of the study, adaptive capacity. The next section will review the literature on the attributes of a farmer with high adaptive capacity.

2.3. The attributes of a farmer with high adaptive capacity

In this study, the aim is to identify a case farmer who has high adaptive capacity, so that the processes they use to adapt to climate change can be investigated. To do this, it is important to define the criteria that will be used to identify such a case farmer. This section reviews the literature on the attributes that have been

identified in relation to farmers with high adaptive capacity. As such, the focus is on the farmer's attributes, not those of the farm. Literature has been drawn from the farm management discipline to provide a foundation on the attributes of farmers with high adaptive capacity. This is then followed by literature that has been drawn from the social-ecological systems and general resilience literature where relevant, that have postulated additional attributes that are important in relation to adaptive capacity. The normative literature has also been drawn upon to complement the empirical farm management literature and to provide additional attributes, traits and/or capabilities that may be important to farmers with high adaptive capacity.

Among the farm management literature, little research has been undertaken into the farmer attributes linked to a high level of adaptive capacity in relation to the context of this study – that is New Zealand hill country sheep and beef farmers and climate change. Duranovich (2015) identified various farmer attributes linked to the adaptive capacity of dairy farmers in New Zealand. Firstly, Duranovich (2015) reviewed the normative literature to identify the attributes of self-efficacy, locus of control, willingness to accept change and uncertainty, sense-making, open-mindedness, and strategic thinking. He then used this knowledge to develop a survey that captured respondent's resilience and adaptive capacity attributes and their risk profiles. In his study he identified a subset of the most important attributes. Duranovich (2015) found that highly resilient farmer types who demonstrate high adaptive capacity have a greater sense of self-efficacy that is associated with skills and an internal locus of control. Highly resilient farmers also had regular contact with other farmers, or members in the dairy industry which enabled social sense-making through the discussion of industry trends and issues. Regular contact with their social networks was an important way for farmers to acquire new knowledge and ideas. Highly resilient farmers tended to be strategically minded and have a willingness to implement changes to their farm businesses in the face of a turbulent environment. They also tended to implement strategies that aimed at reducing uncertainty. In addition, they recognised that risk provided both opportunities and threats over short- and long-term. Based on this, they could implement strategies that transferred, reduced risk, or took advantage of risk. In addition, highly resilient farmers tended to be more risk averse and proactive in finding ways to cope with risk (Duranovich, 2015).

Eakin et al. (2016) also identified attributes of farm-level adaptive capacity in Central Arizona, in the United States of America in relation to farmers' responses to recent uncertainty in relation to commodity and land markets in the agricultural industry. They used farm-level surveys and in-depth interviews to explore the adaptive capacities of these farmers. Their findings demonstrated that farmers with high adaptive capacity have an interest in learning, capacity for adaptive management and unlike the farmers in Duranovich's (2015) study, high risk-taking attitudes. Adaptive management according to Eakin et al. (2016) relates to a farmer's ability to adaptively manage their farm system despite uncertainty, thus allowing them to receive and be responsive to signals of change. It also involves monitoring resources to maintain their viability.

Other farm management studies in developing countries have identified important attributes linked to the adaptive capacity of small-holder farmers in relation to climate change (Wulansari et al., 2022), and extreme

weather events (Henriksson et al., 2017). Wulansari et al.'s (2022) study identified farmer attributes linked to the adaptive capacity of rice farmers in Indonesia using a survey and semi-structured interviews. Their study indicated that farmers with high adaptive capacity had greater access to knowledge and information through higher levels of education and greater social capital that allowed more regular interactions with agricultural consultants and their farming community. Their awareness of climate change was attributed to their access to climate and weather data. In the other study of small holder farmers, Wulansari et al. (2022) reported that social capital was important for farmers with high adaptive capacity as it enabled them to obtain knowledge, information, experience, and ideas from experienced and knowledgeable farmers and to participate in group learning activities such as field days.

In another study of smallholder farmers, Henriksson et al. (2021) compared the adaptive capacity of two sugarcane farmer schemes in Malawi in relation to extreme weather events using semi-structured interviews. They used a framework that was initially developed for the local level (e.g., Jones et al., 2010), but adapted it to suit the farmer scheme systems assessed in their study. They found that the farmer scheme systems had the capacity and adequate management plans in place to proactively mitigate the effects of extreme weather events (e.g., flooding). They indicated a high level of adaptive capacity as they interacted among their social networks and with grower associations. They obtained more knowledge and tended to access climate information, which indicated a capacity to learn and were more inclined to experiment by taking advantage of opportunities. They tended to be more innovative in their use of new technology. They also integrated rigid and flexible management practices across their farm scheme system, indicating flexibility. They had the capacity to use forward-looking decision-making using a five-year strategic plan and considered future uncertainties by using climate projections for crop modelling (Henriksson et al., 2021).

A range of normative papers have postulated what attributes a farmer with high adaptive capacity would possess. For example, Jones et al. (2010) developed a framework to assess local level adaptive capacity. This framework was developed as a part of the Africa Climate Change Resilience Alliance (ACCRA) programme and includes the following farmer attributes: a high level of social capital, a high level of knowledge and information, they would demonstrate innovation and they would have forward-looking decision-making. Other normative studies have postulated that the level of social, and human capital are important indicators of adaptive capacity (Table 1) (Jones et al., 2017; Mortreux & Barnett, 2017; Vincent, 2007). While, the Intergovernmental Panel on Climate Change (IPCC) has suggested information and skills are important determinants of adaptive capacity in relation to global climate change in general (Intergovernmental Panel on Climate Change, 2001). When comparing the empirical farm management literature to the normative literature, farmer attributes such as social capital, knowledge and information, skills and forward-looking decision-making postulated in the normative literature have also been identified in the empirical literature as important attributes for adaptive capacity (Table 1). Among the social-ecological and general resilience literature there have been various attributes postulated specifically to adaptive capacity illustrated in Table 1 (Berkes & Turner, 2006; Carpenter et al., 2001; Dessai & Hulme, 2007; Fazey et al. 2007; Folke et al., 2003;

Gunderson & Holling, 2002; Lebel et al., 2006; Marshall, 2007; Marshall & Marshall, 2007; Nelson, Adger, & Brown, 2007; Olsson et al., 2004; Whitney et al., 2017).

Table 1 Farmer attributes identified in empirical and normative farm management literature versus attributes postulated in social-ecological and general resilience literature.

Empirical Farm Management Literature	*Normative Literature*	*Social-ecological and general resilience literature*
Self-efficacy	Self-efficacy	
Learning, information, and skills	Knowledge and information Information and skills	Skills, knowledge, learning
Internal locus of control Proactive behaviour	Internal locus of control Proactive behaviour	Recognising, monitoring, and responding to effective feedback mechanisms in the environment Proactive behaviour
Willingness to change	Willingness to change	Willingness to change
Individual sense-making	Individual sense-making	Sense-making
Social sense-making	Social sense-making	Sense-making
Social networks Social capital	Social capital Interconnectivity Human capital	Social capital
Strategic mind-set/thinking Innovation	Strategic thinking Innovative Forward-looking decision-making	Strategic thinking Possessing creativity and innovation, identifying solutions or adaptation options
Adaptive management ability		Employing adaptive management approaches
Risk averse/risk perception/risk-taking attitudes		Managing risk High risk-taking attitude
Flexible/flexibility		Learning to live with change and uncertainty Testing and experimenting with options and possessing flexibility
Strategic planning		Strategic planning Planning capacity Nurturing diversity for reorganisation and renewal, and creating opportunities for self-organisation

Duranovich (2015), found that social sense-making was identified as an important attribute, in the normative literature, and he found it to be an important attribute of resilient New Zealand dairy farmers. The social sense-making process links to social capital and an individual's networks. It has seldomly been mentioned in the social-ecological systems and general resilience literature. However, social-ecological systems author Folke (2003) is one of a few who has postulated that sense-making is an attribute linked to resilience and adaptive capacity. However, Folke (2003) did not distinguish between social and individual sense-making. In contrast, Duranovich (2015) did make this distinction. Nelson et al. (2010) similarly postulated the characteristic of being able to reorganize novel information, which may also be described as a form of individual sense-making. Having reviewed the literature on attributes of a highly resilient farmer with high adaptive capacity the following section will summarise these attributes and provide a brief explanation of each. These attributes are self-efficacy, an internal locus of control, social and individual sense-making, social capital, strategic thinking and planning, proactive behaviour, willingness to change, or learning to live with change and uncertainty.

2.3.1. A summary of attributes of a farmer with high adaptive capacity

This section provides a brief definition and explanation to summarise those attributes which have been identified in the literature as being important for high adaptive capacity. Firstly, *self-efficacy* has been defined as "the belief in one's capabilities to organise and execute the courses of action required to produce given levels of attainments" (Bandura, 2000, p.18). Strong self-efficacy beliefs are associated with strong risk-taking attitudes which enable individuals to manage risks effectively (Krueger & Dickson, 1994). Individuals with strong self-efficacy beliefs are likely to perceive risks as opportunities, rather than threats (Bandura, 1997, 2010; Gist, 1987). The interaction between self-efficacy beliefs and perception of risk is important for understanding the influence that self-efficacy has on recognising and taking advantage of opportunities in decision-making (Krueger & Dickson, 1994). At the cognitive level in psychology, human behaviour is regulated by forethought. Thus, self-efficacy is believed to influence decision-making, through regulation of goals. Goal setting is an important aspect of self-efficacy as it is influenced by one's own capabilities and confidence in their own ability (Bandura, 2010).

An *internal locus of control* is linked to self-efficacy (Bandura, 2010; Skodol, 2010) and is concerned with an individual's general expectancy or belief in their ability to control events and outcomes (Rotter, 1966). Resilient individuals and those with a high adaptive capacity are said to have an internal locus of control and "believe that they have considerable control over external events" (Skodol, 2010, p.114). An individual with an internal locus of control will also be aware of external factors and how these factors affect the business (Skodol, 2010). These individuals will put in place contingency plans or reserves to minimise the impacts of risk and will learn from past events. An individual with an internal locus of control will therefore take responsibility for the management of events and their situation rather than blame other factors (e.g., the weather) or other individuals (Shadbolt & Bywater, 2005). An internal locus of control is associated with

skills that are relevant to coping with uncertain environmental events (Skodol, 2010). Individuals with an internal locus of control are commonly referred to as proactive managers (Shadbolt & Bywater, 2005) who are motivated and committed to finding solutions to unexpected problems. This is an indication of *proactive behaviour* (Skodol, 2010).

Sense-making can be both individual and social (Klein et al., 2006a). It is commonly defined as "a motivated, continuous effort to understand connections (which can be among people, place, and events) to anticipate their trajectories and act effectively (Klein et al., 2006a, p.71). In the sense-making literature, at the individual level, sense-making is described as a cognitive process. This process occurs when a particular event in the environment forces an individual to make sense of their current situation (Klein et al., 2006b). It involves retrospective rationalisation to search for meaning in the environment and make sense of the individuals' actions (Klein et al., 2006b). The sense-making process is ongoing where an individual develops plausible meaning about a situation that is built on bracketing the cues from the environment and interpreting these (Nell & Napier, 2005). Sense-making can also be approached as a social construction, where social capital and networking provides individuals with the information for sense-making. Links are made with peers who provide the individual with sources of information and knowledge that can help them understand new situations. This then helps them to adapt to changing environments (Weick, 1995). *Social capital or social networks* relate to the interactions and relationships that a farmer or individual has with their peers, family, friends, scientists, agricultural extension agents, farm consultants or advisor as well as other in their rural community or locality (Duranovich, 2015; Henriksson et al., 2017; Wulansari et al., 2022).

Strategic thinking and planning are described by Graetz (2002) as two different, but interrelated attributes that reflect different types of thought processes that play complementary roles within strategic management. Strategic thinking is said to be creative and intuitive, and it is used to seek innovation and imagine new and very different futures that may lead a firm to redefine its core strategies and even its industry (Graetz, 2002). In contrast, to the creative nature of strategic thinking, strategic planning defines the control mechanisms that are used to implement strategy once it has been determined (Mintzberg, 1994). Graetz (2002) has described the approach of strategic planning as a vital role to realise strategy and to support the new strategies that were developed through strategic thinking and integrate them into the business. Thus, both approaches are arguably linked to the strategic decision-making process.

A *willingness to change*, as well as *learning to live with change and uncertainty* are interrelated attributes, which concern a farmer's willingness to face the reality of change, uncertainty, and ambiguity (Boxelaar et al., 2006). They are associated with having the flexibility and adaptability to undertake change or to make changes where situations are uncertain and ambiguous, and to cope with incremental change in the environment (Marshall et al., 2012). Farmers with these attributes positively embrace change and this is reflected in their pro-active behaviour and risk-taking attitudes (Henriksson et al., 2017; Marshall et al., 2012; Shadbolt & Bywater, 2005). Having reviewed the literature on attributes of a farmer with high

adaptive capacity the following section will explore the literature on a farmers' operating environment and their vulnerability to climate change.

2.4. Understanding a farmers' operating environment and their vulnerability to climate change

In this study, the aim is to understand the processes that a resilient farmer with a high level of adaptive capacity uses to identify change in their operating environment and develop strategies and associated tactics to mitigate and/or take advantage of such change. As such, to understand how farmers identify change in their environment, it is useful to understand what constitutes their environment. This is because not all of elements in the external environment to a farm business are relevant to decision-making. Shadbolt and Bywater (2005) have referred to the environment that is relevant to a farmer's decision-making process as the "operating environment". As such, Section 2.4.1., will review the literature on a farmer's operating environment. Given the focus in relation to the operating environment is climate change, Section 2.4.2., will review the literature on the emerging and anticipated impacts associated with climate change affecting New Zealand pastoral systems. Section 2.4.3., will then review farmers' vulnerability in relation to climate change.

2.4.1. The farmers operating environment

A farmer's external environment consists of four key dimensions which have been identified by farm management authors Boehlje and Eidman (1984). The four dimensions include the institutional components (e.g., regulations), the social components (e.g., society, consumers, other actors outside the farm gate), the physical environment (e.g., weather) and the economic environment (e.g., markets). Martin and Shadbolt (2005) separated it into Political, Economic, Social/Cultural and Technological (PEST) dimensions. Later work has added the Legal and Environmental dimensions (PESTEL) based on the work of Johnson et al. (2009). There is an infinite environment outside the boundary of the farm system, of which the majority is not perceived as relevant to an individual farmer (Boehlje & Eidman, 1984). The external environment outside the farm system that is relevant to a farmer is known as the "operating environment". A farmer's perceptions of their operating environment are subjective and context dependent (Martin & Shadbolt, 2005). Therefore, different farmers may have differing operating environments because of what is relevant to them (Boehlje & Eidman, 1984). A farmer's experiences and knowledge, means their perception of the elements in their operating environment will differ and influence what they can and cannot control. These elements will either have a direct or indirect effect on farmer behaviour, thus affecting their farm management (Boehlje & Eidman, 1984).

A farmer's operating environment rarely remains stable and in more recent times is seen as becoming increasingly turbulent (Chappell, 2019; Gray et al., 2011), but it is also more complex than previously conceived (Milestead et al., 2012). A farming system has been characterised as an open system and can be considered as a complex adaptive system (Petit, 1978). This is due to complex feedback loops and

interactions, whereby changes are highly unpredictable (Milestead et al., 2012). Gunderson and Holling (2002) suggested that social-ecological systems cycle through various types of change which vary in speed and predictability. Holling (2001) described these as adaptive cycles, which relates to different stages (growth, conservation, collapse, or reorganisation) through which a system may pass in response to a changing environment (Holling et al., 2002). When an adaptive cycle is applied to a farming system, it differs in production purpose and the farmer deliberately attempts to control the environment and escape environmental disturbance. The adaptive cycle concept is not commonly used in farming systems research, but it can be used to guide an individual's understanding of the changes occurring in the operating environment (Darnhofer et al., 2008b).

Most of the time, a farm system is in the forward loop, where predictability and stability are at equilibrium (Darnhofer et al., 2008b). This means that risk events have some probability of occurring based on historical or past experiences (Darnhofer et al., 2008b). However, uncertainty may still exist in a relatively stable environment due to the unpredictable events that may occur, which are difficult to assign a possible probability of occurring (Chapman et al., 2007). These unpredictable events are short and episodic stages of back loop dynamics, where instability occurs, leading farmers to look for opportunities of reorganization and innovation. It is likely that systems may spend prolonged periods of time in relative stability where gradual incremental changes are the norm and in which shocks will occur suddenly (Darnhofer et al., 2008b). Thus, farmers are forced to cope with different challenges over time because of transitioning periods of predictable change and shorter periods of chaotic and unpredictable change where the farm system is exposed to risk (Darnhofer et al., 2008b). Production risk in a farmer's operating environment is a type of risk mostly concerned with the climate and all the factors that affect the level, stability, and quality of production within the farm system (Hardarker et al, 2004).

A farmer's operating environment may expose farmers to a range of changes and uncertainties, which are classified as shocks, and long-term stressors (Darnhofer, 2021; Folke, 2006; Meuwissen et al., 2019; Nicolas-Davies et al., 2021; Spiegel et al., 2021). Shocks are episodic events that are defined as reversible or irreversible events which effect a farming system's functionality and are considered to have temporary effects. However, their impact is dependent on a system's resilience (Darnhofer, 2021; Folke, 2006; Hardarker et al, 2004; Meuwissen et al., 2019; Nicolas-Davies et al., 2021; Spiegel et al., 2021). Examples of shocks are extreme weather events such as drought, hailstorms, frost, floods, and invasive weed and pest species outbreaks. In contrast, stressors develop over time and are a form of a gradual change in a farmer's operating environment (Meuwissen et al., 2019). Long term stressors are likely to increase the spatial and temporal vulnerability of a farming system, and lead to tipping points in a system where critical thresholds are crossed, requiring different responses (Walker et al., 2004). As such climate change is a long-term stressor affecting New Zealand hill country farmers, concerning the frequency, intensity, and severity of anticipated and unanticipated shocks (Meuwissen et al., 2019). Overall, climate change not only brings about a gradual long-term change, but it also brings uncertain shocks that redirect the farming system to respond

accordingly (Walker et al., 2004). As such, the farm operating environment is also subject to range of emerging and anticipated impacts associated with a changing climate which will be explored in the following section.

2.4.2. Emerging and anticipated impacts associated with climate change affecting New Zealand pastoral systems

In addition to climate change and its associated shocks, there is other emerging and anticipated impacts that New Zealand hill country sheep and beef farmers may be expected to cope with. As such these farming systems, are sensitive to production risk which is associated with changes in climate, climate variability and environmental conditions, due to their reliance on the availability of natural resources such as rainfall and temperature for pasture production (Lieffering et al., 2012; Ministry for Environment, 2017; National Institute of Water and Atmospheric Research, 2020). Most hill country sheep and beef farms in New Zealand are reliant on pasture grown in situ as their primary source of feed and rely very little on supplementary feed (Beef and Lamb New Zealand, 2020). This makes these farming systems more vulnerable and exposes farmers to greater risk with changes in climate which can impact on a farm's profitability and sustainability (Beef and Lamb New Zealand, 2020; Ministry for the Environment, 2001; National Institute of Water and Atmospheric Research, 2020a).

In this regard, there are many impacts associated with climate change that hill country farmers may be expected to cope with including feed supply (e.g., quality, quantify, growth patterns, variability, and species), soil erosion and flooding, pasture weeds (e.g., scrub, gorse, thistles), pests and diseases (both pasture and animals e.g., facial eczema, internal parasites, crickets, and grass grub) and availability of water resources. Within eastern regions of the North Island in New Zealand, it is expected that there may be an increased frequency and the potential for more severe droughts due to higher-than-average temperatures, reduced annual rainfall and increased variability (Ministry for the Environment, 2001). It is expected that the seasonality of pasture production may fluctuate more, and this will lead to changes in pasture composition and grazing management (Beef and Lamb New Zealand, 2021d). These changes will affect both the quantity and quality of feed grown for livestock (Beef and Lamb New Zealand, 2021d) and may result in feed shortages occurring during vital periods (e.g., late spring to late autumn).

Pasture yield reductions may become prevalent throughout the East Coast due to longer periods of the year experiencing temperatures of over 25°C thus increasing the risk of drought (Beef and Lamb New Zealand, 2021d; Kenny, 2011). Warmer temperatures may extend the growing season with higher pasture growth rates during autumn and winter, and this may result in farmers to lamb or calve earlier than usual to take advantage of changes in feed supply (Beef and Lamb New Zealand, 2021d). This will require farmers to select animals that have the genetic ability to lamb or calve earlier than normal (Beef and Lamb New Zealand, 2021d). As a result of increases in atmospheric carbon dioxide, temperature, and rainfall variability,

there is likely to be changes in the pasture composition, particularly increases in legumes, weeds, and subtropical species (Beef and Lamb New Zealand, 2021d). However, this will be dependent on the soil moisture availability, temperature, and the current legume and grass species that are present in specific regions (Beef and Lamb New Zealand, 2021d). Subtropical grasses that have a lower feed quality such as paspalum (*Paspalum dilatatum)* and kikuyu (*Cenchrus clandestinus)* may shift southward and become more prevalent within the pasture composition due to changes in temperature and warmer conditions occurring on the East Coast (Beef and Lamb New Zealand, 2021d). Although these subtropical grasses are of lower feed quality in comparison to temperate species such as perennial ryegrass and white clover, they have the potential to provide adequate forage for stock during periods of soil moisture deficit (Kenny, 2011; Ministry for the Environment, 2001). Warmer temperatures may result in a decline of protein concentration and leaf quality of pasture leading to reduced animal performance and reduced feed intake (Beef and Lamb New Zealand, 2021d). Increases in the incidence of extreme weather events such as intense rainfall events and sub-tropical cyclones in western and eastern regions of New Zealand will likely increase soil erosion through slips and landslides on hill country properties. The increasing unpredictable weather cycles (e.g., La Niña/El Niño) may lead to significant production volatility (Beef and Lamb New Zealand, 2021d).

Under changing climate conditions, it is expected that there will be an increase in the range, identity and incidence of the current pests, weeds and disease problems in both pastures and animals (Beef and Lamb New Zealand, 2021d; Kenny, 2011; Ministry for the Environment, 2001). Diseases and pests that are not prevalent in some regions are expected to increase (Beef and Lamb New Zealand, 2021d). For example, sheep in regions where warmer temperatures are more prevalent may observe higher disease challenges such as barber's pole worm (*Haemonchus contortus*), flystrike, and fungal toxins including sporidesmin (causes facial eczema) and zearalenone (reduces ovulation rate in ewes) (Beef and Lamb New Zealand, 2021d). Other diseases may arrive unexpectedly such as *Mycoplamsa bovis*, foot and mouth, and swine flu (Beef and Lamb New Zealand, 2021d). There may be increased risk of weather-related diseases such as ticks and heat stress in animals as temperatures increase which will impact on-farm productivity for sheep and cattle (Beef and Lamb New Zealand, 2021d; Ministry for the Environment, 2001). There may be changes and effects on water availability for stock drinking water as well as for irrigation if it is used on farm. This is a concern particularly for drier regions if rainfall variability increases and climate conditions become drier overtime (Beef and Lamb New Zealand, 2021d; Kenny, 2011). In addition, it is also expected that there will be increased social, economic, and political pressures on pastoral farming in New Zealand due to increasing regulation, thus adding an accumulation of challenges for farmers (Kenny, 2011). The following section reviews the literature relating to a farm system's vulnerability to climate change.

2.4.3. A farm system's vulnerability to climate change

Climate change as well as various emerging and anticipated impacts may contribute to increased farm system vulnerability. As such, the exposure and sensitivity to episodic shocks and the long-term changes associated

with climate change will determine how vulnerable a farmer and their farming system is to changes and uncertainty. Vulnerability has been previously defined in systems theory and social-ecological systems; however, the climate change literature provides a generalised conceptual model of vulnerability (Adgar, 2006; Eakin et al., 2016; Gallopin, 2006; Marshall & Marshall, 2007; Smit & Wandel, 2006; Turner et al., 2003). The vulnerability of any given system is considered as a function of two elements, *sensitivity*, and *exposure* to a specified hazard, or range of hazards (i.e., a hill country farming system is exposed to climate change and un-anticipated shocks such as flooding or droughts) (Smit & Wandel, 2006; Turner et al., 2003). The IPCC defines the extent to which systems are vulnerable to climate change depends on the actual exposure to climate change, their sensitivity, and their adaptive capacity (Intergovernmental Panel on Climate Change, 2001). Within social-ecological systems, the concepts of exposure and sensitivity are separate properties of a system and depend on the interactions between the system's characteristics and the attributes of the climate stimuli (Smit & Wandel, 2006). Exposure refers to the duration, extent, and frequency of climate disturbances influencing the system (Adgar, 2006). In contrast, sensitivity is the degree to which a system will respond to such climatic disturbances (Gallopin, 2006). A farm system's exposure and sensitivity relate to and determine the impacts that occur given the projected impacts of climate change without considering adaptation. The actual impact of such events is the impact that remains after a system has adapted (Intergovernmental Panel on Climate Change. 2001; Reidsma et al., 2010). Thus, exposure and sensitivity are defined as an external and an internal characteristic of a system, respectively.

Adaptive capacity is an important concept for a systems vulnerability to climate change. It refers to the ability to cope with climate change, including climate variability and extreme weather events, and involves moderating potential damages, taking advantage of emerging opportunities, and/or coping with the impacts associated with climate change (Intergovernmental Panel on Climate Change, 2001). All agricultural systems are considered human-dominated ecosystems (Eakin et al., 2016; Marshall & Marshall, 2007). Therefore, an agricultural system's vulnerability to climate change will be dependent on the likelihood of the system experiencing such conditions. It will also be dependent on the biophysical effects of climate change on the system and the responses (adaptations) taken or exploited by the manager to reduce and/or mitigate the impacts of climate change (Eakin et al., 2016; Marshall & Marshall, 2007). These responses are dependent on the adaptive capacity of the farmer and the farm system. Having reviewed the literature on a farmer's operating environment, and a farm system's vulnerability to climate change, the next section reviews the literature on the adaptation process.

2.5. Adaptation: A review of the adaptation process

This section of the literature review focuses on the adaptation process that a farmer with a high level of adaptive capacity uses to a) identify a change in their operating environment, b) determine the nature and impact of such change on their farm system and c) formulate a suite of strategies and associated tactics to adapt to that change in relation to climate change. Section 2.5.1., will provide an overview of the concept of

adaptation, followed by Section 2.5.2., which will review various process models from the normative and empirical farm management literature, and the adaptive management literature which are relevant to a farmer's adaptation process. Additional studies will be included where relevant that address other types of adaptation.

Key stages from these adaptation models will be reviewed in the subsequent sections. Section 2.5.3., reviews the literature on how a farmer scans and identifies a change in their operating environment followed by Section 2.5.4., that reviews the literature on sense-making and its relevance to the adaptation process. Section 2.5.5., reviews the literature on farmer's perception of climate change and its associated impacts followed by Section 2.5.6., that provides an overview of the levels of management. Section 2.5.7., reviews the literature on the process a farmer uses to formulate a suite of strategies to adapt to change. Section 2.5.8., reviews the literature on the process a farmer uses to implement strategy. The last section (2.5.9) reviews the literature on the process a farmer uses to monitor and evaluate an implemented strategy to enhance learning and build capacity.

2.5.1. The concept of adaptation

Firstly, to understand the adaptation process used by farmer with a high adaptive capacity, it is important to understand the concept of adaptation and the types of adaptation that may occur within the process. Adaptation has been described by several farm management scholars (e.g., Grothmann & Patt, 2003; Smit & Wandel, 2006) as strategic, or tactical adjustments within agricultural systems in response to actual, or anticipated stimuli. The strategic and tactical adjustments are changes in the practices, processes, and structures of the agricultural system. The adjustments are implemented to reduce the impacts of stimuli or benefit from new opportunities that such stimuli expose the agricultural system to (Grothmann & Patt, 2003; Smit & Wandel, 2006). Adaptive capacity or adaptability is important for adaptation at the farmer level as it is "the capacity of actors in a system to influence resilience' (Walker et al., 2004, p.1) and is often associated with changes that are occurring in the underlying environment, such as climate change (Folke, 2006). As such the process of how a farmer adapts to change in relation to climate change may be largely based on what changes are impacting a farmer's operating environment and their farm system.

According to Smit et al. (1999) and Grothmann and Patt (2003), the most common dimensions in adaptation research on individual behaviour (e.g., farmer decision-making) are related to the timing, and the temporal and spatial scope at which adaptation occurs. The first dimension distinguishes adaptation as proactive or reactive. Whereby the former relates to the capacity to anticipate a shock or stressor before it occurs. The latter, reactive adaptation refers to adaptation that is performed in response to climate stimuli or a shock (Brooks & Adgar, 2005; Smit & Wandal, 2006). Adaptation within agricultural systems can vary and is dependent on the nature of the anticipated climatic stimuli (pro-active adaptation) or the nature of the stimuli it is responding to (reactive adaptation). Adaptation will also vary across different farm types, and in

response to other underlying external conditions such as the economic, political, and legislative environment (Smit & Skinner, 2002). The second dimension distinguishes the temporal scope of adaptation between strategic adaptations and tactical adaptations (Risbey et al., 1999). Strategic adaptations are long-term adaptations, whereas tactical adaptations are short-term adjustments that can be made within a season, month, week or daily (Risbey et al., 1999). The spatial scope of adaptation can occur at the localised level (e.g., plot scale) or they can be widespread e.g., across the entire farm (Risbey et al., 1999, Robert et al., 2016). According to Smit and Skinner (2002), adaptations can be categorised into different areas:1) farm production practices, 2) farm financial management, 3) technological developments and 4) government programs and insurance.

Within New Zealand, intensively managed pastoral systems such as dairy systems are likely to have a higher capacity for implementing adaptive interventions (Lee et al. 2013), whereas extensive hill country sheep and beef systems have limited options for adaptation. Short-term tactical adjustments to the farm system such as the importation of feed, moving stock between regions, strategic timing, and application of fertiliser, or reducing stock numbers in response to pasture shortages in drought are examples of tactical adaptations that can be implemented quickly and easily without any long-term investment. Such adaptations have been reported by Gray et al. (2008, 2011). Other short-term options include harvesting and storing extra pasture and/or forage crop produced in spring, or purchasing imported supplementary feed (e.g., maize silage) to supplement pasture shortages (Keller et al., 2018). In contrast, adaptive interventions that are strategic in nature include the introduction of irrigation, changing the pastoral system, changing the livestock mix, or transforming the land use to another use that is more appropriate for the land topography (Keller et al., 2018; Lieffering et al. 2016). However, the practicalities of implementing irrigation on steep hill country in New Zealand is difficult due to its steep topography (Lieffering et al. 2016). Other options include altering the ratio of sheep to cattle, changing the timing of lambing or calving, diversifying the composition of pasture, and introducing drought-tolerant pasture species (e.g., lucerne) (Skinner et al. 2006; Rojas-Downing et al. 2018). The partial conversion of pasture to forestry offers the opportunity to diversify income through timber production, or gaining carbon sequestration credits (Keller et al., 2018). Having reviewed the concept of adaptation, it is important to provide a foundation on the adaptation process. A range of process models will be reviewed from the literature to develop a theoretical framework for understanding this process which will be used to help guide this study.

2.5.2. An overview of adaptation process models

The adaptive management process can be described as an ongoing process which combines aspects of assessment and management actions to learn about the complexity of an adaptive system (e.g., farm system) and to achieve a set of objectives and goals (Holling, 1978, Walters, 1986). The assessment of a system requires a manager to synthesise relevant information to generate a set of alternative explanations about a set of resource problems that is occurring in the adaptive system (Gunderson, 2015). In the adaptive

management process,s the management actions are designed in a way that considers actions that buffer and reduce uncertainty or vulnerability in the system through adaptation or managing risk (Gunderson, 2015; Holling, 1978; Walters, 1986). Management's actions are then evaluated by monitoring system indicators in a process that utilises information to promote learning (Walters, 1986). Although the assessment and management action phases are described as linear, the adaptive management process is iterative in nature, and helps to develop a dialogue for understanding and evaluating the functioning of an adaptive system (Gunderson, 2015).

Figures 3 describes the process of adaptive management from the social-ecological systems literature. The process begins with an assessment of the environment and the resource problems which managers are faced with. The assessment phase helps to define the resource problem and is then followed by the designing possible solutions or actions to resolve the problem. These management actions will be implemented to resolve the problem. Depending on these actions they can be described as active or passive adaptive management actions according to Walters (1986), with the former being intentional proactive actions and the latter being non-intentional which utilise natural ecosystem variation to create an effect on managed resource variables (Gunderson, 2015). Social-ecological systems author Holling (1981) developed one of two adaptive management processes in which he described three interacting spheres of activity (Figure 3). The first is the resource problem assessment (Figure 3) and the management actions (right of Figure 3). During the assessment phase a range of models and simulations are used to develop a plausible set of hypotheses about the resource issues. This information is then used to develop policy options which are tested and evaluated prior to being implemented (Holling 1981).

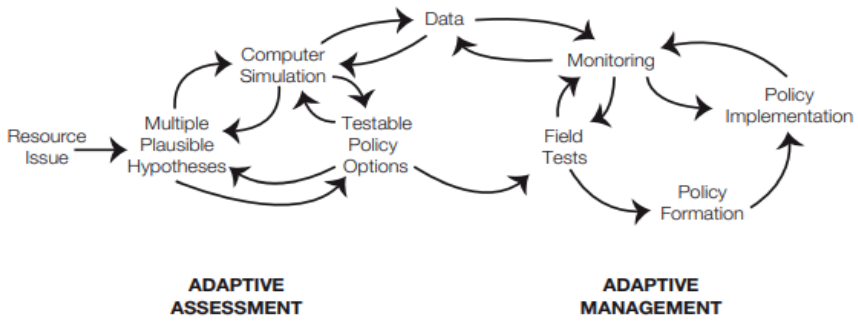

Figure 3 A conceptual model of adaptive environmental assessment and management. The process integrates processes that assess, propose, test, and evaluate hypotheses of ecosystem dynamics and implementation actions (Holling, 1981).

The second model of adaptive management (Figure 4) is from the environmental resource management literature and was developed by the US Department of Interior Adaptive Management working group (Williams et al., 2009). It is similar to the model developed by Holling (1981). The problem assessment is at the beginning of the adaptive management process, followed by the design of actions and implementation. This process involves active monitoring, evaluation, and adjustment to such actions.

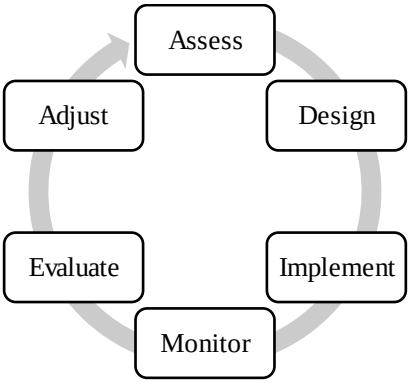

Figure 4 An adaptive management process adapted from United States Department of Interior (Williams et al., 2009).

Holling's (1981) model (Figure 3) focuses on alternative hypotheses in developing and testing policies prior to policy selection for implementation, whereas Williams et al.'s (2009) model has a singular assessment phase, followed by design and implementation. Both models illustrate distinct steps that focus on assessment, implementation, and evaluation. The adaptive management models place importance on monitoring (Gunderson, 2015), whereby monitoring has been described by Holling (1981), and Williams et al. (2009) as a tool to guide the evaluation of outcomes from the management actions that are implemented to build a managers' understanding of the environment and the resources required for individual learning (Gunderson, 2015; Jiggins & Roling, 2000).

Other frameworks have been developed in the normative farm management literature provide some relevance to the adaptation process such as the one developed by Risbey et al. (1999). Risbey et al.'s (1999) model (Figure 5) postulates the process of how farmers adapt to climate variability and change, and highlights farmer decision-making elements of adaptation in uncertain times, and emphasizes the multiple spatial and temporal scales on which a farmer processes information on changes within their environment. The model was developed to gain a perspective of what role climate variability and change has on agricultural adaptation. The model includes four simple stages as illustrated in Figure 5. The first stage is signal detection which involves the decision-maker (e.g., the farmer) defining what is a signal and what noise is based on their own perception of variability or change that is occurring in their environment. The manner and form of adaptation that occurs will be dependent on how the farmer defines these concepts.

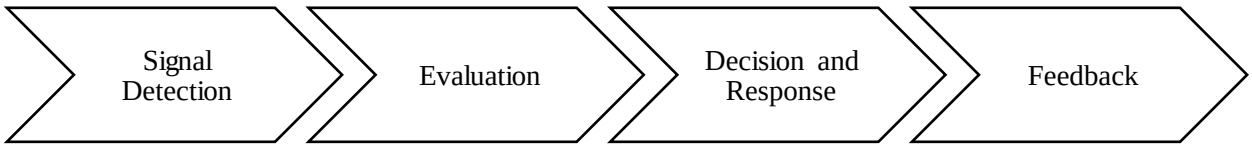

Figure 5 A conceptual decision-making framework for agricultural adaptation to climate variability and change (Adapted from Risbey et al., 1999).

The second stage of the process involves interpreting and evaluating a detected signal to understand the foreseeable consequence of such signal. The third stage is the decision and the response, where once a

decision has been made, a response will follow which is described as "an observable change in the behaviour or performance of the system" by Risbey et al. (1999, p. 139). The final stage of this adaptation process is feedback, which involves monitoring the outcomes of decisions made in the third stage to assess whether they performed as expected. If the decision is effective, it can be added to a suite of adaptive options, however if it is ineffective, further evaluation is required. Risbey et al.'s (1999) model does not suggest that farmers automatically adjust to changes in their environment and optimise their behaviour to suit such conditions. But instead, it suggests that farmers initiate adaptation when they perceive signals that are relevant to their decision making and such signals suggest that adaptation is required to cope with uncertainty within their environment (Risbey et al., 1999). This also suggests that different farmers may perceive the environment differently and hence respond in different ways.

Another model in the empirical farm management literature that is relevant to this study is that developed by Sutherland et al. (2012). It is known as the "Triggering Change" cycle, and it describes a farmer's decision-making process in response to a major change in farm level trajectory. Sutherland et al. (2012) used information about a range of organic and conventional farmers from the United Kingdom that had been collected in an earlier study (e.g., Sutherland, 2010; Sutherland, 2011) to describe major on-farm change processes and land use decisions made in response to a range of triggers. These on-farm changes were not specifically in relation to changes in the environment per se, but instead were in relation to triggers either relating to the life cycle of the farm household (e.g., succession, retirement, and labour availability) or those relating to the farm business that did include factors external to the farm system (e.g., land availability, commodity prices, regulations, and subsidy schemes) (Sutherland et al., 2012). They argued that owing to path dependency, farmers maintain a steady course of action with minor incremental changes until an accumulation of 'triggers' leading to a 'trigger event' occurs, or an opportunity emerges. These events trigger the decision to consider implementing new practices to cope with such events. Once the practices are implemented and meet their anticipated expectations, the farm system will return to path dependency (Sutherland et al., 2012).

The "Triggering Change" cycle consists of five stages (Figure 6). The first stage is path dependency, where the farm manger maintains a steady course of action with minor incremental changes to the farm system along the existing trajectory until the second stage. The second stage is when a trigger event or opportunity occurs which will lead the farmer to consider if minor or major changes are required within the boundaries of the farm system. It allows the farmer to realise that change is necessary to meet their farm management objectives and/or exploit new opportunities. The third stage involves an active assessment, where the farmer will scan for information and become actively focused on available options. This process is repeated and includes a practical assessment of options, the current farm system, and its available resources. It also involves experimentation and networking with farmers or advisors. The third stage considers the economic, managerial, and social implications of making changes to the system (Sutherland et al., 2012).

Figure 6 The "Triggering Change" Cycle (Sutherland et al., 2012).

The fourth stage is implementation, which involves a farmer making a choice and implements a new practice or suite of practices. It commits a farmer to making a financial investment into structural or practice changes. During this stage, a farmer may develop and gain new skills, knowledge and establish new social networks. The final stage of the cycle is consolidation, whereby the farmer utilises new skills, knowledge and networks and evaluates the structural and, or practice changes. If the new practice or structural change is unsuccessful, the farmer returns to stage three to re-assess. This may weaken the capacity of the farmer and farm system to implement new changes if large investments have been made, which may be irreversible (Sutherland et al., 2012).

The strategic management literature also provides insight into a farmer's adaptation process. The strategic management process developed by Martin and Shadbolt (2005) has several important concepts that are relevant to the process of adaptation. Their strategic management process consists of eight key steps including: 1) developing a vision, strategic intent, and long-term goals, 2) evaluating the current situation, 3) undertaking a gap analysis, 4) generating alternative strategic options, 5) evaluating alternative strategic options, 6) choosing the preferred strategy, 7) implementation of the preferred strategy, and lastly 8) monitoring and evaluation. Martin and Shadbolt's (2005) process begins with developing the vision, strategic intent, and the long-term goals of the farm business. The second step focuses on understanding and assessing the farm business's current situation (e.g., on-farm resources) and the current performance of the farm business. Using this information, the strengths (S) and weaknesses (W) of the business are identified. It also involves assessing the external environment that the farm business operates in to identify opportunities (O) and threats (T) that it is exposed to. This analysis is commonly known as a SWOT analysis.

The third step involves a gap analysis to identify the gap between the current situation and the desired position in the future. This is determined by comparing the farm vision, strategy, and long-term goals with the current situation of the farm business. The farmer develops measures that can be used to determine the extent of the difference, and these are used to assess the size of 'the gap' (Martin & Shadbolt, 2005). The fourth step focuses on generating alternative strategic options to reach the desired position. This is carried out by selecting strategic options that are available to the farmer. The number of potential strategic options for implementation can be limited by using the vision, strategic intent, long-term goals, and the current farm

situation to focus the search. The SWOT analysis is typically used to guide the strategic direction of the farm business and provide the farmer with other strategic options (Martin & Shadbolt, 2005). The fifth step involves the farmer analysing the alternative strategic options, while the sixth step involves the selecting the preferred strategy. During this phase, Martin and Shadbolt (2005), suggest incorporating an evaluation component where the farmer evaluates the extent to which each alternative strategy matches the farm business vision, strategic intent and long-term goals, and the associated strategic risk. The seventh step focuses on implementing the preferred strategy by organising the necessary human, physical and financial resources, to support strategy implementation (Martin & Shadbolt, 2005). The final step involves monitoring and evaluating this strategy by comparing the performance of the strategy with planned or expected targets via a farmer's control process (Martin & Shadbolt, 2005). Within the strategic management literature there tends to be different models of the same process (Nell & Napier, 2005; Martin & Shadbolt, 2005), however they are all variations of Martin and Shadbolt's (2005) process that draw from the classical strategic theory (e.g., Ginter et al., 1985).

All the models highlighted, show some degree of similarity, particularly with either identifying a resource problem (Holling, 1981; Williams et al., 2009), analysing the external environment to identify opportunities and threats (Martin & Shadbolt, 2005), detecting a signal in the external environment (Risbey et al., 1999) or detecting a trigger event (internal or external) (Sutherland et al., 2012). They all undertake an active assessment of the farm system and/or internal environment prior to strategy planning and then implement a practice change. Similarly, they follow a similar process for evaluating their decisions after they are implemented. During the evaluation or consolidation stages if a decision is not successful, all models suggest there may be a feedback process, particularly the strategic management process (Martin & Shadbolt, 2005) and Sutherland et al.'s (2012) "Triggering Change" cycle. The models highlighted in this section comprise of the three management functions of planning, implementation and control that are recognised by Shadbolt and Bywater (2005) to some degree. The various models in the review vary in their complexity and the number of steps they show. The models by Holling (1981), and Martin and Shadbolt (2005) comprise of eight stages, Williams et al.'s (2009) model has six steps, whereas Risbey et al. (1999) and Sutherland et al. (2012) have condensed their models to four and five stages, respectively. However, Martin and Shadbolt's (2005) model represents the strategic process that may be used by farmers and emphasises the importance of the mission, vision, and goals of the farming business, which may be particularly important for when farmers are adapting their systems, because it ensures: 1) that the adaptation is in line with their goals and values and 2) clarity in strategic direction and control. The models conceptualised by Risbey et al. (1999) and Sutherland et al. (2012), and the adaptive management models (Holling 1981; Williams et al., 2009) do not mention values or goals.

French (2009) was critical of the strategic management models because they used concepts of linearity, equilibrium, and predictability, but placed little emphasis on learning and cognition. In contrast, the adaptive management process, emphasises learning as a major element (Holling, 1981; Williams et al., 2009). The

classical models (e.g., Martin & Shadbolt, 2005; Nell & Napier, 2005) were developed in a time where the external environment was relatively stable and predictable. However, as uncertainty increases in the external environment the classical models may need to be modified to reflect the turbulent environment farmers are now operating in. Thus, it may be useful to incorporate elements of the adaptive management models, and more recent change process models (e.g., Sutherland et al., 2012) into the strategic management process. Importantly, Risbey et al.'s (1999) model is the only model that focuses specifically on how farmer's should adapt to climate variability and change. Similarly, Sutherland et al.'s (2012) model is one of the few that is based on empirical research. Despite these limitations, the process models reviewed in this section provide useful concepts for thinking about the adaptation process that a New Zealand hill country sheep and beef farmer may use to cope with climate change. The following sections will review the literature on the key steps in the adaptation process, beginning with section 2.5.3., on how farmers identify a change in their operating environment.

2.5.3. The process farmers use to scan and identify a change in their operating environment

The previous section suggests that an important first step in the adaptation process in relation to climate change is to identify that there is a change in the operating environment. Most of the models suggest that this is an important first step in the process (e.g. Holling, 1981;, Risbey et al., 2009, Sutherland et al., 2012; Williams et al., 2009) although some of these focus on a change in the external environment (Risbey et al., 2009) while others consider both a change in the system and the operating environment (Hollings 1981; Sutherland et al., 2012; Williams et al., 2009). Martin and Shadbolt's (2005) strategic management process undertakes an internal analysis and scans the external operating environment for threats and opportunities, but this occurs after developing a vision, strategic intent, and long-term goals. This latter point is not mentioned in the other models, but this may be taken as a given, that these have already been developed by the manager.

The process of scanning and identifying a change in the operating environment was called 'identifying a resource problem' by Holling (1981) and Williams et al. (2009), 'recognising a signal' (Risbey et al., 1999), 'recognising a trigger event' (Sutherland et al., 2012) or 'identifying an opportunity or threat in the external environment' according to Martin and Shadbolt (2005). However, there is limited empirical farm management literature that describes this process.

Firstly, the adaptive management models (e.g., Holling, 1981; Williams et al., 2009) refer to carrying out an assessment of resource problems to define and learn about the complexity of the adaptive system when resource problems (e.g., water availability or pests outbreaks) occur (Holling, 1978; Walters, 1986). Through continuous monitoring the manager learns to identify the important variables within the ecosystem to monitor. This could indicate that a manager consistently monitors, identifies, and then assess various resource problems (Holling, 1978; Walters, 1986; Williams et al., 2009). Holling (1998) describes the

adaptive assessment of a resource problem as two different modes of science, and argues that the first mode focuses solely on the specific parts of the system and analyses them to reduce uncertainty in the environment. The other view is integrative and takes on a holistic approach for searching for simple structures and relationships that help explain the ecological complexity of such problem (Holling 1994). These approaches provide the foundation for the adaptive management as they acknowledge that surprise is unavoidable, and knowledge of uncertainty is incomplete (Gunderson, 2015).

Risbey et al.'s (1999) model of climate adaptation, has a first stage that involves detecting a signal within the environment by defining what is a 'signal' and what is 'noise'. A managers definition of these two concepts is based on their individual perception of climate change and depends on the manner and form of adaptation that occurs. What constitutes a signal and noise relate to what is being adapted to (e.g., climate variability or change) and what is ignored in the process, respectively. Risbey et al. (1999) suggests that signals can be detected on various spatial and temporal scales, and recognises that individuals make decisions differently. Farmers with an operational focus on differing temporal and spatial scales for example may define a signal as "the processes in which they can observe at their characteristic scale of attention" (Riseby et al., 1999, p. 139). This relates to what scale (operational, tactical, strategic, or structural) a farmer defines as important and pays attention to. For adaptation to occur, the detection of a recognisable signal is required. This means that signals on differing temporal scales (short, medium, or long-term) need to be recognised in order to make a decision (tactical or strategic). Such signals could include changes in short-term weather (e.g., rainfall) or changes in climate (e.g., weather cycles such as La Niña and El Niño) over multiple years. Farmers may ignore signals depending on their interpretation of what is relevant and may search for signals on one temporal scale but may not search or monitor signals on another (Risbey et al., 1999).

Sutherland et al. (2012) describes identifying change as encountering or anticipating one or more triggers that leads to a trigger event. These triggers can be classified into two types, those relating to the life stage of the farm household or those related to the farm business. Examples of farm household triggers are succession, injury, or sudden death while farm business triggers might include new market opportunities or failures which lead to what is described as a 'trigger event'. A trigger event is the accumulation of experiences from multiple triggers which leads the farmer to identify that a major change in farming practices or activities is required. A farmer's recognition and identification of triggers and a trigger event can also be positive or negative, suggesting that a trigger event can present an opportunity or a threat to the farming system (Sutherland et al., 2012).

Findings from Sutherland et al. (2012) are parallel to the strategic management models postulated in the strategic management literature. For example, Ginter et al. (1985), French (2009), Martin and Shadbolt (2005), Nell and Napier (2005) and Shadbolt (2007) have described identifying change in the external environment through a situational analysis. The external environment can be analysed as a component of a SWOT analysis and thus be used to determine the nature and the impacts associated with climate change

through a process of deduction. Although the SWOT analysis firstly involves identifying the strengths and weaknesses of the farm business, it can also be used to identify the opportunities (O) and threats (T) that are within the farm's operating environment. It involves identifying opportunities that will help the farm business to create competitive advantage and threats which may impede the performance and productivity of the farm business (Martin & Shadbolt, 2005; Mintzberg et al., 1998). An important aspect of a SWOT analysis is the use of scenarios where the farmer can develop scenarios that show what the impact of a threat or opportunity will be on the business (Nell & Napier, 2005).

Much of the literature follows a similar process for identifying change in the operating environment. It not only involves observing, or recognising signals of change (Risbey et al., 1999), or analysing the external environment (Ginter et al., 1985; French, 2009; Martin & Shadbolt, 2005; Minztberg et al. 1998; Nell & Napier, 2005; Shadbolt, 2007), but also recognising that on-farm practice change may be necessary due to positive or negative triggers (Sutherland et al., 2012). Such triggers present threats and opportunities for farmers on different temporal or spatial scales (Sutherland et al., 2012). The identification of change initiates a farmer to process information about such change and thus begin the adaptation process (Risbey et al., 1999. This suggests that the sense-making literature may be useful to help explain this process. A farmer's process of identifying change in their operating environment is based on farmer's perceptions and expectations of the unknown as well as future weather, forecasted market conditions, expected changes in input prices, and the time horizon or scale that relates to a particular decision (Risbey et al., 1999). Changes occurring in the underlying environment may not always be directly related to climate change per se but may be indirect. Farmers with a high adaptive capacity should have the capacity to identify change that is not only related to climate change but also other types of change that influence the farm system (Smit & Skinner, 2002). Having reviewed the literature on the process farmers use to identify a change in their operating environment, a useful concept that might provide further insight into this is sense-making. The following section provides a review of the sense-making literature and its application in the adaptation process.

2.5.4. Sense-making and its application to identifying change in the operating environment

Another body of literature that provides useful insight into how a farmer scans and identifies change in their operating environment is the organisational management literature on the sense-making process (e.g., Klein et al., 2006a; Klein et al., 2006b; Weick, 1995). The sense-making process may be important to the adaptation process as it enables a farmer to make sense of a situation (or changes in the operating environment) and determine if it is relevant to their decision-making. Sense-making can be classified into two types: individual and social (Klein et al., 2006a; Klein et al., 2006b). Individual sense-making is where an individual makes sense of a situation, whereas social sense-making is where an individual uses their social networks to help make sense of a situation (Klein et al., 2006a; Klein et al., 2006b). Sense-making is a person's capacity to scan information from their environment and interpret such information during, or in anticipation of situations of change and uncertainty (Klein et al., 2006a; Klein et al., 2006b; Weick, 1995).

Sense-making is a routine and continuous construct according to Weick (1995). Sense-making involves extracting cues from the environment to help the individual decide what information and changes are relevant to them. The recognition of a cue is likely to 'trigger' the individual to develop further meaning of what may be going to happen or what is happening in their environment. It is important to consider that sense-making is useful within the adaptation process as it focuses on cue extraction from the environment and helps the individual develop meaning and seek new information to make sense of the change (Klein et al.,2006a; Klein et al., 2006b; Weick, 1995). This may be particularly important in a turbulent environment as a farmer may need to make sense of new information on changes and the risks that their farm system may be exposed to.

There is limited empirical farm management literature that describes the process of how a farmer identifies a change in their operating environment at the strategic level where foresight capacity and long-term decision-making is required to cope with uncertainty in the environment. Much of the research to date focuses on identifying changes at the tactical level such as the empirical work by Tisch and Galbreath (2022). Drawing from the environmental management literature, in a study of New Zealand dairy farmers, Tisch and Galbreath (2022) identified three forms of sense-making used by these farmers during drought events to make sense of changing conditions. The first form of sense-making is based on a farmer's personal experience with regular climatic changes. Farmers make sense of the changing climate and weather based on their experience on-farm and managing these changes regularly. Their immersion in the environment and absorption of the unfolding reality drives the routine scanning of their environment (Tisch & Galbreath, 2022). The second form of sense-making is achieved through the monitoring of physical indicators (e.g., stock, pasture production) on farm to make sense of current conditions. They do this by observing conditions on farm through regular farm walks which provides them with important visual feedback about the farm's state. Farmers also use a range of sensors or instruments (e.g., soil thermometers, a rainfall gauge, a rising plate metre) to monitor and quantify changing conditions (Tisch & Galbreath, 2022). The last form of sense-making is influenced by external actors. A farmer's social network, (e.g., local farmers in the same area) share similar connection to their community, place, and farm locally. Trust is easily built among farmers due to their connection to the land and daily immersion in the farm environment. Trust enables open engagement and interaction among farmers where they can offer advice and share stories and experience (Tisch & Galbreath, 2022). The sharing of experiences and the provision of advice helps them detect cues early, which can help identify changing conditions that then prompts decision-making (Tisch & Galbreath, 2022).

Based on the work of Tisch and Galbreath (2022), farmers may extract cues and identify changes within their operating environment using one of three forms of sense-making or a combination. The use of science and climate forecasting models which transfer information and knowledge about climate change or illustrate predictions (including the weather) were largely disregarded by the dairy farmers in their study as the forecasts were too broad to account for the micro-conditions that farmers cope with every day in their farm

systems (Tisch & Galbreath, 2022). Tisch and Galbreath (2022) found that farmers sense-making efforts are continuous, every day, and via lived experience and immersion in the natural farming environment, not via climate science or forecast information. The farmers ability to deal with slow-onset events such as drought is via the experience gained through working on the land to support their livelihood and sustain their business. Dairy farmers understand the importance of material (e.g., natural objects including land, grass, cows) and measure such material objects to make sense of how drought and the daily weather impacting on their livelihood. The natural material objects provided cues to the dairy farmers that they use to make sense of changing climatic conditions (Tisch & Galbreath, 2022).

Although Tisch and Galbreath's (2022) research focuses on making sense of changing conditions in relation to drought at the tactical level only. They did not investigate foresight capacity and long-term decision-making at the strategic level in relation to climate change. Tisch and Galbreath's (2022) findings could provide insights into how farmers utilise tactical monitoring to develop an understanding of the changes occurring in their environment over time. It is suggested that a farmer's information scanning processes and environmental observations are specific to their farming system and is dependent on several factors including the farmer's level of education, knowledge, experience, aptitude, and attitude (Boehlje & Eidman, 1984). These factors determine how a farmer perceives such elements in their operating environment and how relevant they are to themselves and their farm system (Boehlje & Eidman, 1984; Martin & Shadbolt, 2005). In the next section, the literature on farmers' perception of climate change and it's impacts is reviewed.

2.5.5. Farmers' perception of climate change and its associated impacts

The nature of the farmers' operating environment is both a function of a farmers' perception and knowledge about what is relevant to their farming system and the elements that alter the control over a farm business (Öhlmér et al., 1998). As the external world continues to change, the farmer's operating environment is also changing. Therefore, a farmer's perception of these environmental elements may change as their goals and perceptions change over time (Öhlmér et al., 1998). Farmer learning increases their knowledge and influences their perception about what they can and cannot control in their operating environment (Öhlmér et al., 1998). Farmers are said to differ in their experiences, learning and knowledge, and their perceptions of which elements in the environment they can influence, or control (Shadbolt & Bywater, 2005). As such the extent of the environment in which a farmer operates in is largely knowledge-based, thus it is important to understand how a farmer perceives climate change and how they determine the nature and impacts associated with such change. However, there is little empirical research that describes how New Zealand hill country sheep and beef farmers perceives the nature of climate change and then determines its associated impacts.

Several empirical farm management studies (Gandure et al., 2013; Hyland et al., 2016; Woods et al., 2017) outside of New Zealand have investigated farmer's perceptions of climate change. Some of these are in the context of developed countries such as Denmark (Woods et al., 2013), and Wales (Hyland et al., 2016)

whereas Gandure et al.'s (2013) study is in a South African context. These studies take different approaches to investigating farmer's perceptions of climate change. For example, Woods et al. (2017) and Hyland et al. (2016) used surveys to assess how farmers perceive climate change. In contrast, Gandure et al. (2013) used focus group discussions to characterise farmers livelihood risks from climatic and non-climatic risks.

Woods et al. (2017), found that Danish farmers were moderately concerned or uncertain about the impacts of climate change and most believed that it will have neutral effects on their farms. Farmers were relatively unconcerned about a variety of specific climate change impacts but were most concerned about severe storms causing damage to structures and trees on farm. They also perceived barriers to the adoption of adaptations such as the environmental, climate and farming regulations placed on farmers. They stated that these were restricting their adaptation behaviour. Farmers indicated a likelihood to adapt to climate change in the foreseeable future, however their adaptations would be aimed at taking advantage of the opportunities and positive impacts of climate change. They also found that farmers who were concerned about climate change were more likely to adapt to mitigate the negative impacts of climate change. Farmers indicated a preference to alter their current farming system where possible, to optimise gains from the positive impacts of climate change rather than adapt to the negative impacts. Farmers preferred to make incremental changes over time and incorporate additional flexibility into their system by making small alterations to farm practices when necessary to take advantage of potential opportunities and reduce risks (Woods et al., 2017).

Gandure et al. (2013) found that regardless of farmers age or gender they agreed that the climate is changing. Farmers' perceptions of the changing climate correlated with the long-term changes observed in climate data. Based on the farmers' perspective, both rainfall variability and extreme temperatures had minimal impact on their livelihoods. However, the accumulated effect of rainfall and temperature were perceived to have an impact. Farmers expressed a greater concern for other impacts such as weeds, insects, and internal parasites on production as well as poor physical and human security which is associated with lack of infrastructure and fencing to protect crops and livestock from theft and weak access to markets to sell primary products. Farmers acknowledged there are long-term changes in climate, however their view of "climate change" was based on the short-term effects that were currently occurring. The adaptation strategies implemented by farmers in the study were not deliberately targeted towards rainfall variability and temperature impacts but were associated with a combination of climatic and non-climatic limiting factors such as water shortages, poor soil conditions, and lack of farming equipment and agricultural extension (Gandure et al., 2013). Farmers in Gandure et al.'s (2013) study believed that the potential impacts of climate change were irrelevant as they were not occurring on the time scales that currently influence their on-farm decisions.

Hyland et al. (2016), Gandure et al. (2013) and Woods et al. (2017) all reported that farmers were uncertain about the opportunities and threats if any that climate change might bring. The main opportunity identified in Woods et al.'s (2017) study was a longer growing season and in contrast, the greatest risk was from unpredictable and extreme weather. Hyland et al. (2016) also reported that farmers in their study were aware

that climate change is happening, a finding also reported by Gandure et al. (2013) and Woods et al. (2017). Hyland et al. (2016) classified the farmers in their study based on their responses and identified four types of farmers. The first type was "the environmentalists" who were more likely to adopt mitigation measures to climate change as they had the greatest awareness of this. Another group of farmers, "the dejected" had high behavioural capacity to implement adaptation measures but lacked understanding about climate change and how livestock farming generated emissions. The third group "the country-side steward" had a high motivation to act pro-environmentally but lacked awareness of climate change. The final group "the productivist" were not as pro-active as other groups as they had low motivation to act pro-environmental due to their production dictating their management decisions. They also had low levels of climate change awareness. Hyland et al. (2016) raised the issue that understanding farmer types may be an important factor in identifying their behavioural capacity for adaptation, and to understand farmer awareness and perceptions of risk. Many of the studies (Gandure et al., 2013; Woods et al., 2017) identified that pursuit of opportunities from climate change by farmers may be attributed to their willingness to make changes and adapt to climate change.

Although the farmers investigated in these studies (e.g., Gandure et al., 2013; Hyland et al., 2016; Woods et al., 2017) have recognised climate change is occurring, they do not perceive climate change and its associated impacts as relevant to their current on-farm decisions. This may suggest that what is occurring in their current operating environment does not suggest that climate change is a major risk to their farming system at this point in time. However, these farmer's perceptions may change in the future when climate change has a much greater impact and risk to their farming system. Prior to reviewing the literature on strategy formulation, the following section reviews the different levels of management decisions used by farmers so that the nature of strategic decision-making is clear relative to tactical and operational decision-making.

2.5.6. Farm management: The levels of management

Within farm management, there are different ways of classifying management decisions. These include by level, field, and type of decision (Boehje & Eidman, 1984; Gray 2001). Management decisions can be classified into three levels known as strategic, tactical, and operational (Boehje & Eidman, 1984). The three levels of management refer to a hierarchy in which goals and plans are set to achieve different purposes for the farm business (Cowan et al., 2012; Shadbolt & Bywater, 2005) (Figure 7). The top level of this hierarchy is the strategic decisions (e.g., farm business strategy). The strategy of a farming business, according to Shadbolt and Bywater (2005) refers to the purpose of how 'value' for the farming businesses will be created for the shareholder or owner-operator. Strategic decisions within a farm business are decisions that are concerned with what is going to be produced (outputs) and how the business is going to be organised in terms of the farm system dynamics to produce such outputs. Strategic decisions involve making assumptions about the future and considering what the outlook of the farming system and operating environment may be

in the long-term. These are typically linked to the unknown, rather than the known, hence they are made, based on a farmer's assumptions about the future (Shadbolt & Bywater, 2005; Shadbolt, 2008). Strategic decisions are said to involve a planning horizon of 5 to 10 years according to Gray (2001). These decisions tend to be infrequent, often involve a large investment, and have considerable long-term impacts on the farm business's future (Shadbolt & Bywater, 2005). Strategic decisions influence and drive the lower two levels of management, that is the tactical and operational decisions (Shadbolt & Bywater, 2005).

Figure 7 Example of a hierarchy of plans and goals in a farm business (Adapted from Cowan et al. 2012).

Strategies and tactics often exist within the hierarchy of planning (Figure 7) and are quite distinct from one another, particularly in terms of the way a strategy or tactic is formulated and how they are implemented in the farm business (Wright, 1984). Once the farm system has been organised in such a way to produce the outputs through strategy recognition, tactics are commonly used to change or alter the inputs within the production process (management practices) to produce such outputs. Strategies and tactics are commonly distinguished in terms of their spatial frame over which they are applied to the farm system. However, they are commonly mistaken for one another due to the long production cycles of a farm system (Cowan et al., 2012). The tactical level of management forms the link between strategy and day-to-day operational requirements on the farm (Gray et al., 2009). It is concerned with the implementation of planned strategy with the aim of maintaining efficiency through the efficient acquisition and allocation of resources (Gray et al., 2009; Shadbolt & Bywater, 2005).

The planning horizon for tactical decisions is comparatively less than that estimated for strategic decisions, whereby Gray (2005) previously suggested tactical decisions in a dairy farm business are associated with a planning horizon of 3-12 months. Tactical planning and decision-making involve determining within year adjustments to a farm strategy such as a selling policy or pasture management policy to fit the prevailing circumstances that are influencing the farm system (Cowan et al., 2012). Trafford and Gray (2012) stated that due to the nature of tactical management, tactical decisions are made much more frequently. This is due to tactical decisions being repeated, and the decision problems and their solutions being accurately defined by the farmer (Trafford & Gray, 2012). Tactical decisions are concerned with efficiency in which the day-to-day operations are both implemented and controlled. The final level of management is the lowest level;

operational. The operational planning horizon is much shorter than the higher two levels of management (Shadbolt & Bywater, 2005) and has previously said to be concerned with a 1 to 30 days' time frame to operate the farm effectively (Parker et al., 1997). Overall strategic decisions have the greatest impact on the farm output and farm profitability whereas operational has the least. Although operational planning occurs the most frequently, strategic planning occurs the least, thus it is important to recognise the most purposeful strategic fit for the farm business (Shadbolt & Bywater, 2005). The following section will review the literature on strategy formulation.

2.5.7. The process used by a farmer to formulate a suite of suite strategies to adapt to change

Within the adaptation process, it is important to understand the process used by a farmer to formulate a suite of strategies and associated tactics to adapt to a change in the operating environment. This involves the creative process of formulating strategy that aims to take advantage of, or reduces the impacts associated with climate change and other impacts occurring within the micro and macro environment (Martin & Shadbolt, 2005). Drawing from the strategic management literature, Martin and Shadbolt (2005) postulate that a critical component in the strategic management process is comparing the desired outcomes with the expected outcomes of the farm business. This is carried out by comparing the farm vision, strategy, and long-term goals with the current situation of the farm business. The farmer develops measures that can be used to determine the extent of the difference and then assesses the size of 'the gap' using these measures. It determines whether the farm business is in a suitable situation, or not for managing the future conditions and provides an indication on how significant the situation may be. If 'the gap' of the current strategy is too large to meet the desired outcomes, then there is a need to consider alternative strategies or develop new strategies (Martin & Shadbolt, 2005).

Alternative strategic options can be selected from a pool of strategic possibilities, which are available to the farmer. The number of strategies that have the potential to be implemented can be narrowed down by using the farm business vision, strategy intent, long-term goals, and the current farm situation to focus the search. The SWOT analysis may be a useful tool to assess farm system's capability and to develop strategic options (Martin & Shadbolt, 2005; Mintzberg et al., 1998; Shadbolt, 2007). Martin and Shadbolt (2005), suggest the strategic management process incorporates evaluating the extent to which each alternative strategy matches the farm business's vision, strategic intent and long-term goals, and the strategic risk associated with each strategy, prior to selecting a preferred strategy (Martin & Shadbolt, 2005; Nell & Napier, 2005). The preferred strategy should aim to reduce risk and be able to cope with underlying conditions in the environment (Shadbolt, 2007), particularly in the context of climate change. It is important for a farmer to consider a mix of strategies that may be suitable to cope with the impacts associated with change (Martin & Shadbolt, 2005) however, this is determined by the availability of on-farm resources (Nell & Napier, 2005).

Among the farm management literature, there is very limited empirical research that describes the strategy formulation process used by farmers. However, in a case study of three New Zealand dairy farmers by Beijeman et al. (2009), they reported that the farmers identified new strategies using a range of techniques including using their social networks and identifying new strategies through monitoring the external environment. The farmers also purposefully searched for new strategies via industry links, maintaining strong social networks within and outside of the dairy industry, and keeping up to date with various information sources (Beijeman et al., 2009).

Among the normative farm management literature, it has been suggested that strategy formulation involves utilising a combination of farmer judgement, intuition, experience, and past learning (Martin & Shadbolt, 2005; Nell & Napier, 2005). A farmer's management of their farm system may be largely informal and based entirely on farming experience, intuition, and visual observation, whereas other farmers may undertake objective measurements and formalised analysis at each stage of planning, implementation, and control (Parker et al., 1993). Chapman et al. (2007) and Sutherland et al. (2012) argued that a farmer should have a good understanding of their farm system to guide strategy formulation. Chapman et al. (2007) suggests that part of the strategic management process involves validating farmer intuition using a range of analytical techniques to forecast the probable outcomes and consequences of strategic options. Analytical techniques can also be referred to as implementation tests (Nell & Napier, 2005). Two farm management studies (e.g., Beijeman et al., 2009; Chapman et al., 2007) identified a range of analytical techniques used by farmers, which can be carried out formally or informally to test the practicality and viability of strategies. Sutherland et al. (2012) argued that farmer use analytical techniques to explore the economic, managerial, and social implications of strategies. Examples of analytical techniques identified within the farm management literature include feed and financial budgeting, risk analysis, sensitivity analysis, scenario analysis, feasibility assessments, and an assessment of competitive advantage (Beijeman et al., 2009; Chapman et al., 2007).

As the strategic management process involves the continuous crafting of strategy to find the best strategic fit for the farm system (Martin & Shadbolt, 2005; Nell & Napier, 2005). It is important to recognise that within the strategic management process, an ongoing situation analysis may be useful and provide meaningful feedback about their strategic risk and exposure, thus sensitising the farmer to the farm businesses capabilities and its environment (Nell & Napier, 2005). Such analysis enables the farmer to recognise emergent strategy and improve one's ability to execute strategy (McLoed & Schell, 2001; Nell & Napier, 2005; Shadbolt, 2007). An emergent strategy is one which emerges during the strategic thinking process and is often a realised pattern of thought (Mintzberg & Walters, 1985). Realised strategy is a combination of rational planning as well as haphazard opportunistic thinking, where the realised strategy does not incorporate an intended or an emergent strategy due to this irregular type of strategic thinking. The intended strategies that a farmer seeks to implement after strategy formulation are not always possible and may in fact be discarded. With time, what may have seemed an impossible strategy previously may become possible and

be adopted (Mintzberg & Walters, 1985). These are known as emergent strategies (Beijeman et al., 2009; Mintzberg & Walters, 1985). Risbey et al. (1999) postulated that the during the decision and response stage of a farmers' adaptation process, strategic options are often disregarded in favour of familiar and routine tactical adaptions. Having reviewed the strategy formulation process, the following section will review the literature on strategy implementation.

2.5.8. The process used by farmers to implement strategy to adapt to change

The process used by farmers to implement strategy to adapt to the impacts associated with change is necessary for adaptation to occur at the farm level. Drawing from the normative farm management literature, implementation is a key function of management (Shadbolt & Bywater, 2005). Implementation is the formal or informal process of placing a strategic plan (or tactical) plan into operation within the farm system (Gray, 2005). The strategy implementation stage commits a farmer to undertaking one or more of the following actions to adapt to the impacts associated with change. Based on the empirical farm management literature these actions are: 1) changing management practices, 2) changing the use of inputs, 3) changing the output mix, and 4) undertaking a capital investment (Gray et al., 2009; Gray et al., 2011; Lieffering et al., 2012). Strategy implementation is supported by the implementation of functional tactics and operational plans (Martin & Shadbolt, 2005). These functional tactics aim to maintain farm efficiency through the efficient acquisition and allocation of on-farm resources (Gray et al., 2009; Shadbolt & Bywater, 2005).

A critical part in the adaptation process described by the strategic and farm management literature (Martin & Shadbolt, 2005; Risbey et al., 1999; Sutherland et al., 2012) is that a farmer must have an appreciation of the resources available to them in their farm system. It is important for a farmer to understand their farm business not just at the physical level, but also at the technical, economic, and financial levels (Nell & Napier, 2005). Within the implementation stage, is it important to organise the necessary on-farm resources in a way that aids strategy implementation at each step of the strategic plan (Gray, 2005). Farm management authors Martin and Shadbolt (2005) have grouped the resources into three broad categories: *biophysical*, *human*, and *financial* resources. Of the *biophysical* resources land is the most important resource within a farm system. Land has many characteristics including, the area, boundaries, contour, location, aspect, climate, and altitude as well as physical characteristics of the soil which include natural fertility and structure. The *human* resources include the management and labour resources of the farm business. They are both necessary to ensure the physical and capital resources can be utilised. The human factor in this category distinguishes it from the other resources. Martin and Shadbolt (2005) suggest that different people have different attributes with respect to education, experience, aptitude, attitude, and personality. This will impact how their skills are utilised in the farm business (Martin & Shadbolt, 2005). The last resource category is the *capital* resources. They comprise the total value of the resources that are deployed across the farm business, including non-land assets. These can be categorised as fixed, medium, or liquid assets. A fixed asset are land and improvements as well as attachments (fences and buildings). A medium asset is the capital that is

committed to maintaining or purchasing of livestock or machinery. Liquid assets are uncommitted capital that is available to pay for a variety of resources (e.g., variable inputs, drawings, interest, and capital payments such as debt, taxation, and new investment) (Martin & Shadbolt, 2005).

There is very limited empirical farm management literature that describes how a New Zealand hill country sheep and beef farmer implements strategy. However, drawing from a case study of three New Zealand dairy farmers Beijeman et al. (2009), they reported that the farmers demonstrated six different strategy implementation sequences. These sequences include: 1) the intended strategy was implemented successfully without being influenced by other intended or emergent strategies, 2) a realised strategy was implemented that was a combination of the original intended strategy and an emergent strategy, 3) no part of the intended strategy was implemented and the realised strategy was the result of a strategy that emerged prior to implementing the intended strategy, 4) the realised strategy that was implemented was a combination of two intended strategies, 5) the original intended strategy is discarded in favour of a different intended strategy, and lastly 6) an emergent strategy is implemented after the intended has been successfully implemented but before the new intended strategy is established (Beijeman et al., 2009). Each of the different strategy sequences suggest as opportunistic way in which farmers can take advantage of opportunities and therefore implement strategy. It also suggests that one farmer implements strategy in a very different way to another farmer and that strategies can also be formulated during the implementation stage. As such once a strategy has been implemented within the farm system, the strategy is then managed via a control mechanism. The following section reviews the literature on how a farmer monitors and evaluates an implemented strategy to enhance learning and build capacity.

2.5.9. The process used by a farmer to monitor and evaluate an implemented strategy to enhance learning and build capacity

Following the implementation of a new strategy, an important function required to ensure successful strategy implementation within the strategic management process, is the control function. The control function is often referred to by several farm management authors (e.g., Gray, 2005; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005) as strategic control and is used for three main purposes including:, 1) to manage the implementation of the plan, 2) to minimise the impact of uncertainty on plan implementation, and 3) to determine when a new plan needs to be developed due to a long-term or dramatic change in the environment (Gray, 2005; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005). Strategic control consists of two key processes, a monitoring, and an evaluation process (Gray, 2005; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005) that would be useful in a farmer's adaptation process. However, little empirical research been undertaken to describe the process farmers use to monitor and evaluate the implemented strategy to enhance learning and build capacity.

Drawing from the strategic management literature, strategic control can be separated into three different types including *preventative*, *concurrent* (feedback) and *historical* control (Gray, 2005). The first type is *preventative* control, which is where an individual will put in place several practices that aim to minimise deviations to the plan before they occur. Preventative controls commonly used in New Zealand pastoral systems include the adoption of preventative animal health programs or capital investment such as the use of irrigation systems to minimise the impact of drought on pasture production. The farmer must have a good understanding of their farm business and its sources of uncertainty to develop such controls, which limits the need for concurrent control (Gray, 2005; Martin & Shadbolt, 2005).

Concurrent control is the second type of control, where deviations from the plan are adjusted in real time (Gray, 2005). It involves the farmer monitoring a range of key factors at regular intervals including production factors (e.g., pasture growth kg/DM/day, liveweight, climatic data), financial factors (e.g., income, expenditure), marketing factors (e.g., sales data, product quality) and human factors (e.g., labour demand/supply). These factors are compared to set targets specified in the plan. If the targets are met, then the farmer will implement the next stage in the plan. However, if such conditions are different from those expected, the cause of deviation is evaluated and a contingency plan is chosen and implemented to minimise impacts from the deviation (Gray, 2005; Martin & Shadbolt, 2005).

The last form of control is *historical* control (Gray, 2005). Gray (2005) reported that farmers use this form of control to monitor the outcome of a completed plan and compare this to the farmer's expected outcomes. If they are different, this identifies a knowledge gap (as opposed to a performance gap) and the farmer then evaluates the gap to enhance his knowledge. This learning is then used to improve the farmer's management for the next planning period. A farmer is likely to evaluate the outcomes of their decisions and their overall decision-making process using historical control (Gray, 2005). Historical control is a mechanism that is central to farmer learning, whereby a farmer will learn about their farming system, management system, their operating environment, and the interactions between these systems to effectively make decisions (Gray, 2005). Each form of control involves an evaluation component, which comprises of two key aspects: 1) learning and based on this, 2) the development of the farmer's adaptive capacity (e.g., Ginter et al., 1985 cited by French, 2009; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005). Learning is central to improving an agricultural system and a farmers' ability to cope and adapt (e.g., their adaptive capacity) to change and uncertainty in the operating environment. Learning involves: 1) the validation of both new and existing knowledge, and 2) knowledge creation (Gray, 2005). Knowledge is one of the most important aspects for building adaptive capacity and helps to improve the management of the farm business at all three levels, e.g., strategic, tactical, and operational (Martin & Shadbolt, 2005). Knowledge is limited in its use unless a farmer can translate it into action that will help them achieve their vision and goals (Gray, 2005; Martin & Shadbolt, 2005).

Similarly, a monitoring and an evaluation component has also been identified within the adaptive management literature (e.g., Gunderson, 2015; Holling, 1981; Williams et al., 2009) as an important aspect. Holling (1981) and Williams et al. (2009) describe monitoring as a tool that assists the evaluation of outcomes from the management actions that are implemented. Monitoring builds not only a managers' understanding of the environment, but the resources required for individual learning in which incremental, iterative, and experimental learning occurs (Gunderson, 2015; Jiggins and Roling, 2000). In addition, Risbey et al.'s (1999) normative model of adaptation for climate variation and change is similar to both the strategic management process and the adaptive management literature. Risbey et al. (1999) refers to the final stage of their model as a feedback stage. This stage involves monitoring the outcomes of decisions made in the third stage to assess whether they are as expected. If the decision (e.g., practice change) is effective and meets the expected outcomes of the farmer then it can be added to a suite of adaptive options, however if it is ineffective, further evaluation is required.

Drawing from the study by Sutherland et al. (2012), the final stage of their "Triggering Change" cycle (e.g., the consolidation stage) involves evaluating the success of the farm system after a new practice or structural change has been implemented. During evaluation, if there is a lack of success with the implementation of the practice, this will enable a farmer to undertake adjustments to their farm system. It may also enable a farmer to return to an earlier stage in the cycle to actively assess the appropriate triggers, and thus formulate new options to better suit the conditions created by the trigger event. Sutherland et al. (2012) considers that an on-farm investment strategy is likely to weaken the ability of a farmer to implement new practices or adjust them, because as investment strategy is often difficult to reverse. Sutherland et al.'s (2012) draws on examples from earlier research (e.g., Sutherland, 2011) to demonstrate that learning is a key aspect within the consolidation stage, particularly on-farm learning by the individual themselves and via social learning. Sutherland et al.'s (2012) findings show that social learning can allow for knowledge sharing, reflection, and the validation of information and knowledge. These findings on evaluation and learning are similar to the work of Gray (2005) and provide support for the normative strategic management literature (Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005) as well as the adaptive management literature (e.g., Gunderson, 2015; Holling, 1981; Williams et al., 2009). However, Sutherland et al. (2012) provides little information on the monitoring process used by the farmers in their study. As such, this suggests that there is limited research that describes how a farmer monitors their implemented strategies.

Within the strategic management literature (e.g., Martin & Shadbolt, 2005) a farmer may be required to utilise further strategic thinking and planning if the control process reveals that a particular strategy has been disrupted, or in the case that the realised strategy differs from the intended strategy for the strategic intent to be achieved. This is due to unforeseen conditions (e.g., uncertainty) which arise in the micro and macro environment, and of which may redirect the farm business from its chosen strategic path. Therefore, it may be necessary for the farmer to re-evaluate the farm business's vision, strategic intent, and the long-term goals. This leads to the strategic management process being retriggered and may prompt substantial change

of the farm business vision, strategic intent, and long-term goals (Martin & Shadbolt, 2005). Sutherland et al. (2012) reported a similar process whereby uncertainty in the environment, the failure of a practice change or the failure of a structural change may retrigger the "Triggering Change" cycle. Following the monitoring and evaluation stages of the farmer's adaptation process new strategy formulation may be initiated. Having reviewed the final stage of the adaptation process that a farmer with high adaptive capacity may use to adapt to cope with the impacts associated with climate change, the following section will summarise the material from the literature review into a conceptual framework for the study.

2.6. Conceptual framework

The literature review brings together the literature into a conceptual framework that comprises of two areas that are relevant to the study: 1) the attributes of a highly resilient farmer with a high level of adaptive capacity (Section 2.6.1), and 2) the adaptation process used by such a farmer to cope with and adapt to the impacts associated with a change within their operating environment in relation to climate change (Section 2.6.2). The following sections set out and explain this conceptual framework.

2.6.1. The attributes of a farmer with high adaptive capacity

This study firstly sets out to identify the attributes of a highly resilient farmer with high adaptive capacity. These attributes will be used to develop criteria that will be used to select a suitable case farmer for this investigation. Based on the literature review, a range of key attributes were identified. Drawing on the empirical farm management literature, Duranovich's (2015) study provided the most relevant evidence of farmer attributes linked to adaptive capacity. Other farm management authors including Eakin et al. (2016), Henriksson et al. (2017) and Wulansari et al. (2022) had identified similar attributes to those identified by Duranovich (2015). However, the terms they used for the attributes in their studies were different to those used by Duranovich (2015), but they were essentially the same attributes. Duranovich's (2015) extensive review of the literature identified a range of attributes including self-efficacy, locus of control, willingness to accept change and uncertainty, sense-making, open-mindedness, and strategic thinking. He then used this literature review to develop a survey that captured respondent's (NZ dairy farmers) resilience and adaptive capacity attributes. In addition, it also captured their risk profiles. The survey identified the attributes of self-efficacy, social sense-making, internal locus of control, capacity to learn to live with change and uncertainty, and strategic thinking which were important in relation to a farmer's adaptive capacity. Although his study was based on New Zealand dairy farmers, the attributes he identified are likely to be applicable to New Zealand hill country sheep and beef farmers because they both run pastoral farm systems and supply their produce to overseas export markets.

In addition to the attributes identified by Duranovich (2015), another farm management study (Henriksson et al., 2021) and a normative article in the social-ecological literature (Whitney et al., 2017) identified strategic planning as an important farmer attribute for adaptive capacity. As such, this has been added to Duranovich's

(2015) set of attributes (Figure 8). Additional sub-categories of the main attributes have been derived from the literature (Figure 8). The attributes in the typology are a mix of capabilities, attitudes, skills, and knowledge.

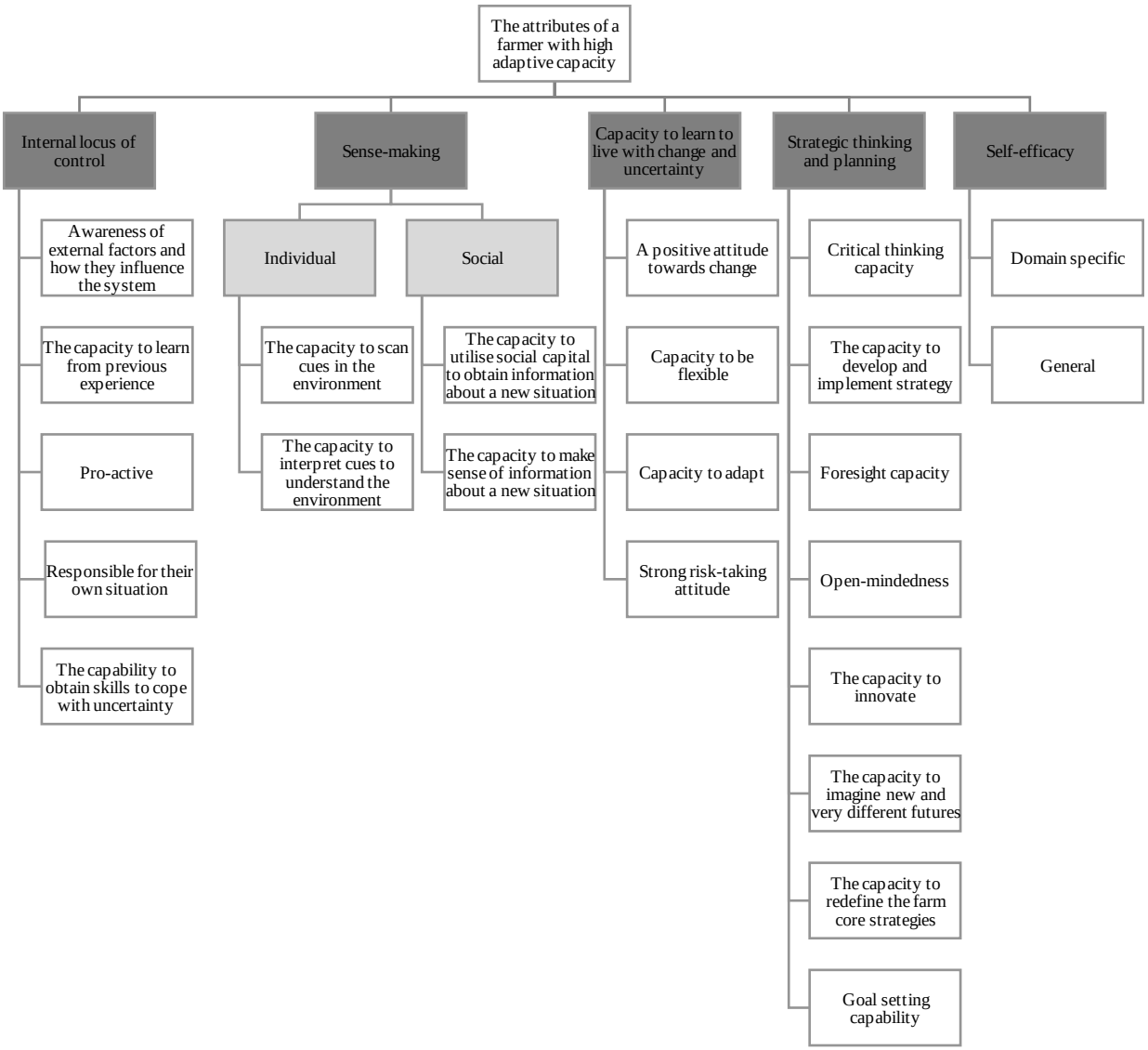

Figure 8 A typology of the attributes associated with a farmer with a high level of adaptive capacity (Adapted from Duranovich, 2015).

The first attribute, internal locus of control (Figure 8) is an individual's general expectancy or belief in their ability to control events and outcomes (Skodol, 2010). Several sub-attributes were identified from the literature including having an awareness of external factors and how they influence the system, the capacity to learn from previous experience (Bandura, 2010). It is also associated with having the motivation to solve

problems, through pro-active behaviour and learning capacity (Bandura, 2010). An important attribute of internal locus of control is that the individual is responsible for their own situation (Skodol, 2010). The final sub-attribute is that they have the capability to obtain the skills needed to cope with uncertainty (Bandura, 2010; Skodol, 2010).

The second attribute, sense-making (Duranovich, 2015) is defined by Klein et al. (2006a) as "a motivated, continuous effort to understand connections, which can be among people, place and events in order to anticipate their trajectories and act effectively" (p.71). It can be usefully separated into two types of sense-making (Figure 8), individual (Klein et al., 2006a, Klein et al., 2006b) and social sense-making (Weick, 1995). Individual sense-making requires an individual to have the capacity to scan and interpret information in situations of change and uncertainty, and to interpret cues to understand the environment (Klein et al., 2006a, Klein et al., 2006b). These attributes are required so that an individual can make sense of the situation and learn about it in a way that enables capacity building (Klein et al., 2006a, Klein et al., 2006b).

In contrast, social sense-making is carried out as a social construction whereby an individual may utilise their social capital (e.g., social networks and trust), to better understand situations of change and uncertainty (Weick, 1995). An important attribute is to have the capacity to interact with others to gain new information, knowledge, and experiences about a situation from an array of different individuals in their social networks (Weick, 1995) (Figure 8). The second important sub-attribute of social sense-making is to have the capacity to make sense of the new information provided by one's social networks. Social sense-making is an important means for a farmer to access new information that is relevant to the perceived future changes in the environment (Weick, 1995). Individual and social sense-making can also be used to capture and take advantage of business opportunities, and reduce exposure to threats (Duranovich, 2015).

The third attribute is the capacity to learn to live with change and uncertainty (Duranovich, 2015). The most important sub-attribute of this is that the individual must have a positive attitude towards change, uncertainty, and ambiguity, and embrace it (Boxelaar et al., 2006) (Figure 8). It is the capacity of an individual to learn and build knowledge around change and uncertainty, while also accepting the need for change if required (Boxelaar et al., 2006; Marshall et al., 2012). The capacity to learn to live with change and uncertainty concerns a farmer's willingness to face the reality of change, uncertainty, and ambiguity (Boxelaar et al., 2006). An individual must also have the flexibility and adaptability to undertake change or to make changes where situations are uncertain and ambiguous, and to cope with incremental change in the environment (Marshall et al., 2012) (Figure 8). It also encompasses strong risk-taking attitudes (Figure 8). Farmers with strong risk-taking attitudes are likely to perceive risk as a source of opportunity rather than threats due to their coping capacity (Bandura, 1997, 2010; Gist, 1987). They are therefore able to manage risks more effectively and recognise the advantages of opportunities in decision-making (Krueger & Dickson, 1994).

The fourth attribute is strategic thinking and planning (Duranovich, 2015; Eakin et al., 2016; Henriksson et al., 2017; Marshall et al., 2012). Although they can be considered as separate attributes, they have been linked because they are interrelated thought processes within the strategy formulation process described in the strategic farm management literature and are complementary to each other (Graetz, 2002). Strategic thinking is described as synthetic, divergent, creative, intuitive, and innovative (Graetz, 2002). Strategic thinking enables a farmer with high adaptive capacity to seek out innovation, imagine new and very different futures that may lead a farm business to redefine its core strategies and even the industry it operates in (Graetz, 2002). Strategic thinking is particularly important for adaptive capacity as it is one of the distinguishing attributes that differentiates it from buffer capacity. Strategic thinking is vital for strategizing for situations of change and uncertainty. It is a necessary attribute to sustain long-term farm business survival and stability in a changing environment (Darnhofer et al., 2010; Folke, 2006; Kaine & Tozer 2005).

In contrast, strategic planning is described as logical, systematic, conventional, prescriptive, and convergent (Graetz, 2002). Strategic planning is a formalised and analytical process that helps to define strategy and involves decision-making concerning resource allocation (Mintzberg, 1994). Strategic planning also emphasises the control mechanism required to implement strategy and it is useful for strategy development which is linked to goal setting capability (Bandura, 2010). Strategic planning is vital for supporting strategy building for the present, and future where uncertainty is inevitable (Graetz, 2002; Mintzberg, 1994).

The attribute of strategic thinking and planning also has a sub-set of attributes that includes the development of critical thinking capacity (Graetz, 2002; Henriksson et al., 2021; Whitney et al., 2017), the capacity to develop and implement strategy (Graetz, 2002), foresight capacity (Graetz, 2002), the attitude of open-mindedness (Duranovich, 2015; Whitney et al., 2017), the capacity to innovate (Graetz, 2002; Mintzberg, 1994), the capacity to imagine new and very different futures (Graetz, 2002), the capacity to redefine the farm's core strategies (Graetz, 2002) and lastly goal setting capability (Bandura, 2010) (Figure 8).

The fifth attribute is high self-efficacy (Duranovich, 2015) which is the belief in one's capabilities to organise and execute the courses of action required to achieve given levels of attainments and goals (Bandura, 2000, p.18) (Figure 8). Self-efficacy is a vital attribute of adaptive capacity as it encompasses personal factors such as forethought, beliefs, and skills (Bandura, 2010). Self-efficacy can be separated into general self-efficacy and domain specific self-efficacy (Figure 8). The former relates to self-efficacy that is associated with confidence in one's own ability to execute control over their own motivation, behaviour, and social environment (Bandura, 2010). It also involves one's abilities and coping capacity for stressful and uncertain events that one may be faced with (Bandura, 2010). In contrast, domain specific self-efficacy is related to self-efficacy for a specific and future focused task. (e.g., a farmer may have domain specific self-efficacy in pasture management) (Bandura, 1997). The following factors influence general and domain specific self-efficacy including actual experiences (success or failure), vicarious experiences (observing the success and failure of similar peers), verbal persuasion (being told by trusted individuals that you will be

successful at a particular task or activity) and the individuals physiological state (Bandura, 1997). Although there are five key attributes that have been identified in the typology, the sub-attributes may not necessarily be mutually exclusive. The next section describes the second aspect of the conceptual framework, the adaptation process used by a farmer with a high level of adaptive capacity.

2.6.2. The farmer's adaptation process

This study set out to understand the adaptation process that a farmer with high adaptive capacity uses to a) identify change within their operating environment, b) determine the nature and the impact of such change on the farm system, and then c) develop and implement a suite of strategies and associated tactics to adapt to the impacts of change in relation to climate change. The literature review highlighted that there is limited empirical farm management research that describes the adaptation process used by farmers in relation to climate change with little research into the adaptation process used by New Zealand hill country sheep and beef farmers.

As highlighted in the literature review, there are several key concepts that were identified from a range of different process models from various disciplines that are useful to apply to the adaptation process. These disciplines include the adaptive management literature (e.g., Gunderson, 2015; Holling, 1981; Williams et al., 2009), the sense-making literature in the organisational management literature (e.g., Klein et al., 2006a; Klein et al., 2006b; Weick, 1995), the empirical environmental management literature (Tisch & Galbreath, 2018; 2022), the normative farm management literature (e.g., Risbey et al., 1999), the empirical farm management literature (e.g., Beijeman et al., 2009; Chapman et al., 2007; Gray, 2005; Sutherland et al., 2012) and the strategic management literature (e.g., Martin & Shadbolt, 2005). The adaptive management literature (e.g., Gunderson, 2015; Holling 1981; Williams et al., 2009) provides useful insight, however, as highlighted in the literature review, the process model described by Williams et al. (2009) is similar to the strategic management process (e.g., Martin & Shadbolt, 2005). The earlier model by Holling (1981) was excluded due to its multiple cyclic process and its emphasis on ecosystem dynamics. The model by Sutherland et al. (2012) provides some useful concepts such as thinking about what triggers a farmer to formulate new strategies to cope with change. Similarly, Risbey et al.'s (1999) model identifies the difference between a signal and noise, and how the identification of a signal and noise may differ between farmers. Most of the models have similar steps such as the scanning or monitoring to identify a change, the assessment of that change to determine its likely impacts on the farm system and then the formulation, implementation, monitoring and evaluation of a new strategy orsuite of strategies to cope with the change.

To illustrate the adaptation process used by a farmer with a high level of adaptative capacity, a hybrid model was developed drawing on the concepts from the various process models reviewed in the literature. The hybrid model integrates 1) a farmer's individual and social sense-making ability to scan information from their environment for cues that indicate change and thus identify change on different temporal and spatial scales within their operating environment, 2) their ability to determine the nature and the impacts associated

with such change on their farm system, 3) their strategic thinking and planning ability to formulate and implement strategy to adapt to the impacts associated with climate change and 4) their ability to monitor and evaluate their decision outcomes to continuously learn and therefore build their adaptive capacity. As such the adaptation process synthesised from the literature comprises of six key stages: 1) scanning the operating environment for cues that indicate a change, 2) identifying a change in the operating environment, 3) assessing the nature and impact of the change on the farm system, 4) formulating a suite of strategies to adapt to the change, 5) implementing strategy to adapt to the change, and 6) monitoring and evaluating the implemented strategy to enhance learning and build capacity (Figure 9). The following sections provide a description of the individual stages in the adaptation process (Figure 9). It draws on the appropriate concepts where relevant from the various disciplines that were reviewed in the literature.

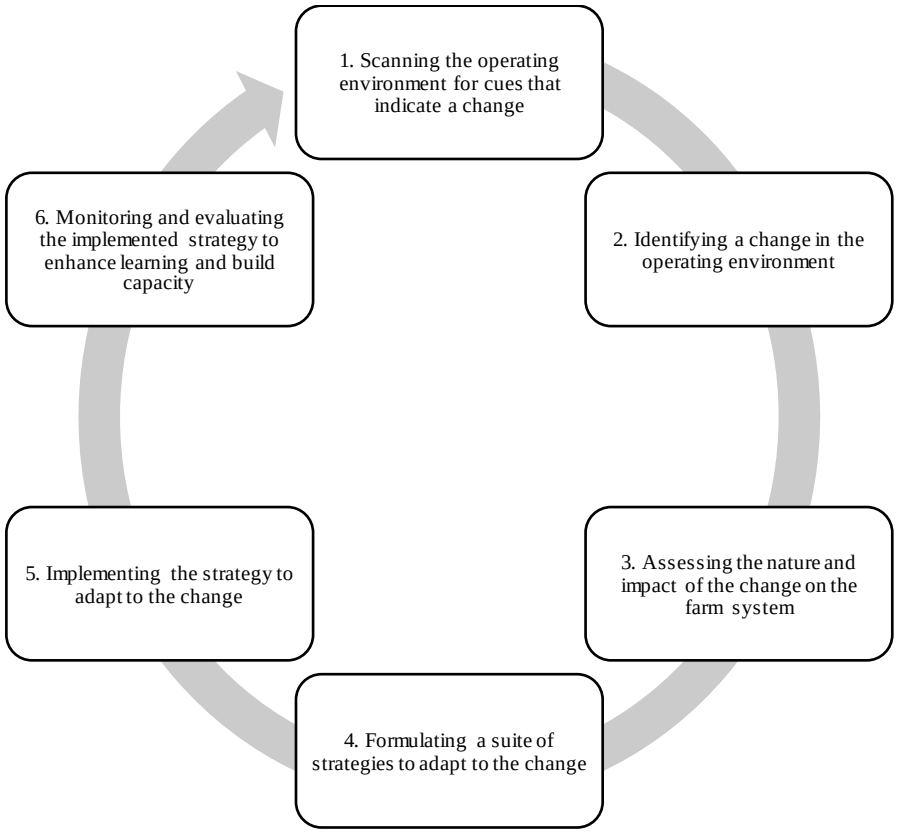

Figure 9 A conceptual framework that describes the adaptation process used by a farmer with high adaptive capacity to adapt to present and future impacts associated with change in their operating environment in relation to climate change.

Scanning the operating environment for cues that indicate a change

The first stage of the adaptation process involves a farmer proactively scanning their operating environment for cues that indicate a change in relation to climate change via the individual's sense-making processes (Klein et al., 2006a,b; Tisch & Galbreath, 2018, 2022; Weick, 1995). Sense-making is an individual's capacity to scan information from their environment and interpret such information during, or in anticipation of situations of change and uncertainty to link the gap between the unknown and known (Klein et al., 2006a;

Klein et al., 2006b; Weick, 1995). Sense-making involves extracting cues (e.g., from information sources or the environment) to help the individual decide what changes in their operating environment are relevant to them (Klein et al., 2006a; Klein et al., 2006b; Weick, 1995). Importantly a farmer's perceptions of their operating environment are subjective and based on a range of farmer characteristics such as level of education, knowledge, experience, aptitude, attitude and the farm context (Boehlje & Eidman, 1984; Martin & Shadbolt, 2005). These characteristics and in particular a farmer's experiences and knowledge, means that their perception of the elements in their operating environment will influence what they perceive they can and cannot control within their farm system (Boehje & Eidman, 1984).

Klein et al. (2006a,b) distinguished between individual sense-making and social sense-making for making sense of a situation. Tisch and Galbreath (2022) identified that individual sense-making could be separated into 1) a subjective process which draws on personal experience and the subjective monitoring of the weather to identify changes in the environment and 2) an objective process where the farmer monitors physical indicators (e.g., stock live weights, pasture production, rainfall, and temperature) using a range of sensors (e.g., soil thermometers, a rainfall gauge, a rising plate metre) on-farm to make sense of current conditions or to anticipate future conditions.

Social sense-making uses information from an individual's networks to make sense of a situation (Klein et al., 2006a,b). The sharing of experiences and advice allows the early detection of cues (Tisch & Galbreath, 2022). Scanning for cues can occur on different temporal and spatial scales (Risbey et al., 1999). A temporal scale corresponds with change over time and is defined by the three levels of management (e.g., operational, tactical, or strategic). In terms of climate and weather, this may be at the operational level (e.g., daily weather conditions), the tactical level (3-12 months, e.g., El Niño or La Niña weather patterns) or at the strategic level (5+ years, e.g., climate change forecasts) (Risbey et al., 1999). A spatial scale may differentiate across different boundaries of space e.g., farm, district, region, country, or the global scale (Risbey et al., 1999). Farmers may also scan for cues that indicate change at one scale, but not necessarily monitor for cues at other scales due to a farmer's scale of attention and what they perceive as relevant to their decision-making (Risbey et al., 1999). This is where Risbey et al.'s (1999) concepts of signals versus noise are useful as it distinguishes between information that farmers consider relevant or irrelevant to their decision-making, of which is context dependent. As such, farmers often view long-term climate change forecasts as irrelevant because they are too far into the future and too unpredictable (Hyland et al., 2016; Tisch & Galbreath, 2018). Such information, because it is often provided at a regional scale often also fails to provide specifics on the local or micro-conditions at the farm scale which are most relevant to farmer decision-making (Tisch & Galbreath, 2022). The next stage is where a farmer identifies a change in the operating environment.

Identifying a change in the operating environment

The second stage in the adaptation process (Figure 9) is a continuation of the sense-making process (Klein et al., 2006a,b; Weick, 1995) that involves the farmer extracting cues from the operating environment that indicates a change. The farmers must decide if the cue is relevant to them in determining if a change in the environment is occurring (Klein et al., 2006a,b; Weick, 1995). This is likened to Risbey et al.'s (1999) distinction between signals and noise. Extracted cues that are important are based on the farmers perception of what elements influence their farm system and which elements they can or cannot control (Boehlje & Eidman, 1984).

A farmer is likely to extract relevant cues (Klein et al., 2006a,b; Weick, 1995) either from a cues derived from individual sense-making (Klein et al., 2006a,b; Weick, 1995) such as such as subjective observations of climate stimuli in the environment (e.g., increased occurrence of extreme weather events) or through measuring material objects and looking for trends (e.g., rainfall and temperature, animal live weight gain and pasture production over the summer) or via social sense-making (Klein et al., 2006a,b; Weick, 1995) using their social networks (e.g., shared experience of changing climatic conditions) (Tisch & Galbreath, 2022).

Cues that indicate change are likely to be extracted from differing temporal or spatial scales (Risbey et al, 1999). The extraction of a cue and the ability of the farmer to recognise it as change triggers a farmer's sense-making effort to develop further meaning of the change by gathering additional meaningful information to develop a larger sense of what is occurring or what is expected to occur (Tisch & Galbreath, 2022). The farmer may choose to obtain information through various information sources (e.g., newspaper, TV, internet) to better understand the influence that change may have on their local climate (Riseby et al., 1999). It may also involve a farmer relying on various social networks to help understand the changes occurring in their operating environment (Tisch & Galbreath, 2022). A farmer is likely to utilise their social networks, e.g., peers, colleagues, agricultural consultants, to assist in their sense-making efforts as well as develop new networks if required to obtain new information and knowledge about changes associated with climate change (Tisch & Galbreath, 2022). Such networks provide emotional support, information, knowledge, and resources to farmers (Tisch & Galbreath, 2022). It is important to consider that, farmers may not necessarily identify change associated with climate change per se, but other changes that are indirectly associated with climate change such as market opportunities or failures that influence the farm system (Sutherland et al., 2012).

Once a farmer has made sense of the situation and identified there is a change in the operating environment, this acts like Sutherland et al.'s (2012) 'trigger event' which may be a caused by a single event (e.g., extreme weather event), but is more likely to be due to an accumulation of triggers (e.g., extreme weather events, other farm data and information from other local farmers indicating a change in climate, regional climate change reports, global information about climate change) that lead to a trigger event. This accumulation of information and experiences results in the recognition that on-farm practice change may be required

(Sutherland et al., 2012). The next stage of the adaptation process is where the farmer assesses the nature and impact of the change on the farm system.

Assessing the nature and impact of the change on the farm system

The third stage of the adaptation process involves the farmer determining the nature of the change and assessing the impacts that such change could have on the farm system (e.g., farm business) (Figure 9). This process involves assessing the foreseeable consequences and impacts of the change through identifying the threats that may need to be mitigated and the opportunities which could be taken advantage (Ginter et al.,1985; French, 2009; Nell & Napier, 2005; Shadbolt, 2007). Drawing from the normative farm management and strategic management literatures (e.g., Ginter et al.,1985; French, 2009; Nell & Napier, 2005; Shadbolt, 2007), the opportunities (O) and threats (T) components of a SWOT analysis are typically used for analysing the external environment. The SWOT analysis can be undertaken informally or formally, and involves a farmer identifying and classifying the external opportunities (positive) and threats (negative) that could influence the productivity and performance of the farm system (Nell & Napier, 2005; Sutherland et al., 2012; Shadbolt, 2007).

In a SWOT analysis, the external factors which could influence the farm system are researched thoroughly to develop an understanding of which external climatic factors (e.g., increased incidence of drought over several years will decrease pasture growth and result in ongoing pasture deficit and thus become a threat to animal performance on-farm) are likely to constitute threats or opportunities to the farm business. Although the SWOT analysis is a tool used to guide the strategic direction of a farm business (Nell & Napier, 2005; Shadbolt, 2007), it can be used to explicitly identify the current situation of a farm business and the impending impacts of change in relation to climate change (Nell & Napier, 2005). However, there is very limited empirical evidence on how farmers conduct a SWOT analysis. There is also not a lot written about how farmers should conduct a SWOT analysis in the strategic management literature (e.g., Martin & Shadbolt, 2005), particularly in relation to climate change adaptation. Once a farmer has carried out the external analysis part of the SWOT analysis to determine the opportunities and threats associated with a perceived change in relation to climate change the following stage begins. The next stage involves formulating a suite of strategies to adapt to the perceived change.

Formulating a suite of strategies to adapt to the change

The fourth stage of the adaptation process is the creative process used to formulate strategy (Martin & Shadbolt, 2005) (Figure 9). Strategy formulation is an iterative process that involves the continuous crafting of strategy to find the best strategic fit for the farm system via an ongoing situation analysis (Martin & Shadbolt, 2005; Nell & Napier, 2005). A situation analysis (e.g., a SWOT analysis) provides meaningful feedback about a farmer's strategic risk and exposure, which sensitises the farmer to the farm business's capabilities and its environment (Martin & Shadbolt, 2005; Nell & Napier, 2005). An ongoing analysis of the farm system will enable the farmer to recognise several alternative strategies and emergent strategy. In a case

study of three New Zealand dairy farmers by Beijeman et al. (2009), they reported that farmers identified new strategies through their social networks and from monitoring the external environment. The farmers also purposefully searched for new strategies via industry links, maintaining strong social networks within and outside of the dairy industry, and keeping up to date with various information sources (Beijeman et al., 2009).

The strategy formulation process can generate several different types of strategies (Beijeman et al., 2009). The number of strategies that have the potential to be implemented can be narrowed down by using the farm business vision, strategy intent, long-term goals, and the current farm situation to focus the search and to select the preferred strategy (Martin & Shadbolt, 2005; Mintzberg et al., 1998; Shadbolt, 2007) to improve one's ability to the execute strategy (McLoed & Schell, 2001; Nell & Napier, 2005; Shadbolt, 2007). Such strategy should aim to reduce risk and be able to cope with underlying conditions in the environment (Shadbolt, 2007), particularly in the context of climate change. It is important for a farmer to consider a mix of strategies that may be suitable to take advantage of opportunities or to minimise the threats associated with the change (Martin & Shadbolt, 2005). The mix of strategies will be determined by the availability of resources on-farm and the role of the vision, strategic intent, and long-term goals play within farmer decision-making (Nell & Napier, 2005).

Among the normative farm management literature, it has been suggested that strategy formulation involves utilising a combination of farmer judgement, intuition, experience, and past learning (Martin & Shadbolt, 2005; Nell & Napier, 2005). A farmer's management of their farm system may be largely informal and based entirely on farming experience, intuition, and visual observation, whereas other farmers may undertake objective measurements and formalised analysis at each stage of planning, implementation, and control (Parker et al., 1993). Chapman et al. (2007) and Sutherland et al. (2012) argued that a farmer should have a good understanding of their farm system to guide strategy formulation. Chapman et al. (2007) suggests that strategy formulation involves validating farmer intuition using a range of analytical techniques (e.g., implementation tests) to forecast the probable outcomes and consequences of different strategic options (Martin & Shadbolt, 2005; Nell & Napier, 2005). Two farm management studies (Beijeman et al., 2009; Chapman et al., 2007) have identified a range of analytical techniques used by farmers, that are both formal and informal, to test the practicality and viability of different strategies. Examples of analytical techniques identified within the farm management literature include feed and financial budgeting, risk analysis, sensitivity analysis, scenario analysis, feasibility assessments, and an assessment of competitive advantage (Beijeman et al., 2009; Chapman et al., 2007). The next stage is implementing strategy to adapt to change.

Implementing strategy to adapt to change

The fifth stage of the adaptation process involves implementing a strategy (Figure 9) (Nell & Napier, 2005; Risbey et al., 1999; Sutherland et al., 2012) to adapt to the impacts associated with the change identified in the operating environment. Strategy implementation commits a farmer to undertaking one or more of the

following actions including: 1) changing management practices (Sutherland et al., 2012), 2) changing the use of inputs, 3) changing the output mix (e.g., sheep and beef) (Cowan et al., 2012), and 4) undertaking a capital investment (Gray et al., 2009; Gray et al., 2011; Lieffering et al., 2012). During the strategy implementation stage the farmer focuses on organising the necessary biophysical, human, and financial resources, to support successful strategy implementation (Martin & Shadbolt, 2005). It also involves implementing lower-level farm management decisions such as functional tactics and operational plans that support strategy implementation (Martin & Shadbolt, 2005). The next stage is monitoring and evaluating the implemented strategy to enhance learning and build capacity.

Monitoring and evaluating the implemented strategy to enhance learning and build capacity

The sixth stage of the adaptation process involves two key processes: 1) monitoring and 2) evaluation. These are the key functions of strategic control as described in the strategic farm management literature (Ginter et al., 1985 cited by French, 2009; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005). Strategic control is used to manage the implementation of the plan, minimise the impact of uncertainty on plan implementation, and to determine when a new plan needs to be developed due to either a dramatic or a long-term change in the environment (Gray, 2005; Martin & Shadbolt, 2005). Strategy can be controlled via *preventative control*, *concurrent control*, and *historical control* (Gray, 2005; Martin & Shadbolt, 2005).

Each form of control involves an evaluation component, which comprises two key aspects: 1) learning and based on this, 2) the development of the farmer's adaptive capacity (e.g., Ginter et al., 1985 cited by French, 2009; Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt & Bywater, 2005). Historical control is closely linked to farmer learning (Gray, 2005), whereby learning is central to improving a farming system and a farmers' ability to cope and adapt (e.g., their adaptive capacity) to uncertainty in the operating environment. Monitoring feedback from the environment and evaluating decisions to build capacity presents the farmer with the opportunity to learn about one's system through incremental, iterative, and experimental learning (Gunderson, 2015; Jiggins & Roling, 2000; Williams et al., 2009). Learning involves: 1) the validation of both new and existing knowledge, and 2) knowledge creation (Gray, 2005). Knowledge is one of the most important aspects for building adaptive capacity and helps to improve the management of the farm business for the next production cycle or planning period (Martin & Shadbolt, 2005). Knowledge is limited in its use unless a farmer can translate it into action that will help them achieve their vision, and goals (Gray, 2005; Martin & Shadbolt, 2005). Based on a farmer's monitoring and evaluation of an implemented strategy, if such strategy is effective, it can be added to a suite of adaptive options (e.g., suite of strategies) or if not, further evaluation may be needed (Risbey et al., 1999). This may therefore retrigger the strategy formulation stage to formulate a strategy that is better suited to cope with the underlying conditions in the operating environment or in general is a better strategic fit for the farm business (Martin & Shadbolt, 2005). Further assessment and sense-making efforts may also be required, which may retrigger the adaptation

process to better understand the operating environment due to the new unfolding reality of climate change (Tisch & Galbreath, 2022).

Chapter Three

3. Method

3.1. Introduction

This study sets out to answer the following research questions:

How does a farmer with high adaptive capacity identify change in the environment in relation to climate change and then adapt their farm system to cope with this?

This chapter sets out the research method used to answer the research question and achieve the objectives (Section 1.3 and 1.4). Section 3.2., describes and justifies the research design used for this research followed by Section 3.3., which provides an overview of the research process. Section 3.4., provides details about the initial review of the theory followed by Section 3.5., which describes the case selection process used in the study. Section 3.6., describes the data collection procedure, followed by Section 3.7., which describes the data analysis procedure. The final section (3.8) describes the ethical considerations of this research.

3.2. The selection of the research strategy

The selection of the research strategy was based on the criteria suggested by Yin (1994, 2002). Yin (1994, 2002) suggested the use of three criteria for the selection of an appropriate research strategy: 1) the type of research question, 2) the degree of control the researcher has over the research phenomena, and 3) the focus of the research and whether it is on an historical or a contemporary event. Based on Yin's (1994, 2002) criteria, a case study research approach was selected. This was because 1) the study sought to answer how and why questions, 2) the researcher had no control over the research subject (e.g., the case farmer), and 3) the focus of the research was on contemporary events. When undertaking a case study, the researcher must choose between a single case and a multiple case design (Yin, 1994, 2002).

A single case design, and more specifically an explorative case study offers the opportunity to explore areas in which take a broad look at the phenomena of interest (Yin, 2002). An explorative single case study allows the study to focus on a particular context of interest (Dey, 1993; Yin, 1994, 2002). Context relates to the object of the study as it occurs or has occurred in real life (e.g., how farmers are adapting to cope with a changing climate) (Yin 1994, 2002). The context for which this investigation focuses on, is "understanding the adaptation process that an East coast hill country sheep and beef farmer with a high level of adaptive capacity undertakes to identify change in relation to climate change in their operating environment and then adapt their farm system to cope with this". The locality context of this case study is on the East coast of the North Island, comprising of the Gisborne, Hawkes Bay and the Wairarapa regions. By selecting a context specific case, e.g., East Coast hill country sheep and beef farming in New Zealand, it allows the research

strategy to be limited to a locality, population of farmers and a particular industry. It also offers the opportunity for future research in the same context to be carried out (Yin, 1994, 2002).

Single case studies are used for cases that focus on investigating a complex process in-depth to develop a description of what is 'going on' (e.g., the adaptation process used by a farmer) and compare such process to the theory (Yin, 2002). Given the complexity of the adaptation process, the researcher decided to use a single exploratory case study design (Yin, 2002). This is to ensure the investigation of the individual case farmer's adaptation process in relation to climate change was undertaken in sufficient depth (Yin, 1984). A case study differs to other research strategies such as an experiment or survey, which isolate factors from the context (Dey, 1993; Yin, 1994). A case study can differentiate the context from factors that are being investigated through the data collection and analysis without disregarding the single case that involves several interactions and complexities (Yin, 1994). The following section provides an overview of the research process.

3.3. An overview of the research process

The explorative case study design used in this study has two key stages: 1) the design stage and 2) the data collection and analysis stage (Figure 10). In the design stage, the research problem was firstly defined (Section 1.2). Based on the research problem, an initial review of the relevant literature was undertaken to draw on key concepts and important relationships within the literature. Drawing from the initial review of the literature, case selection criteria were developed to select a single case (e.g., case farmer). The design of the data collection procedure and protocol was undertaken to support the remainder of the research process (Yin, 1989).

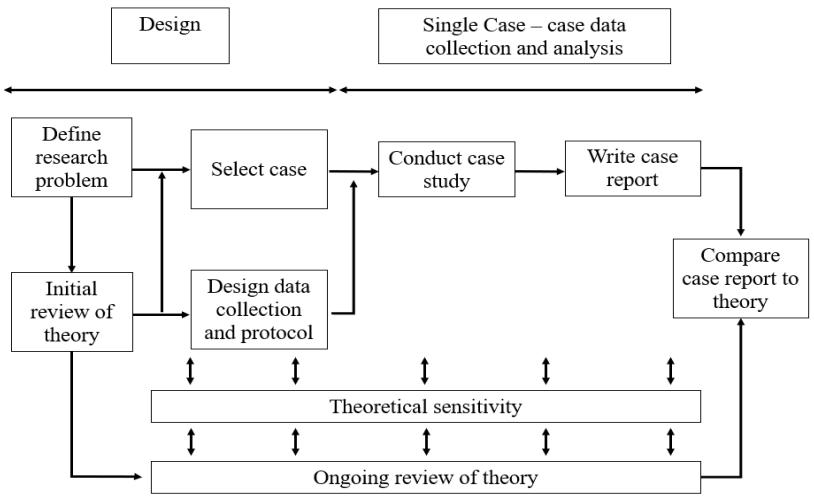

Figure 10 An example of a single case study method framework (Adapted from Yin, 1989).

In the data collection and analysis stage, the data collection procedure including the interview process was undertaken to capture in-depth information about the case farmer and from this the data analysis was undertaken (Figure 10). The data analysis involved undertaking a qualitative data analysis process to develop

a final case report that described the case and phenomenon of interest (Dey, 1993; Miles & Huberman, 1994). The case report was then compared to the theory to find similarities within the literature, close gaps within the literature and highlight new empirical findings (Yin, 1989). The following section provides an overview of the initial review of theory.

3.4. Initial review of the theory

Drawing from Figure 10, once the research questions and objectives have been determined and the research strategy chosen, the first step in the single-case study method is to undertake an initial review of the theory. This defines the key concepts and important relationships in the literature. It also identifies gaps in the literature. A comprehensive literature review was undertaken on the topic of adaptive capacity and the climate change adaptation process (Yin, 1989), and is presented in chapter two. The literature review is an important aspect in this investigation because from this, criteria was chosen for the selection of the single case. It was also used to design the data collection protocol (Figure 10). The literature review helps to develop the theoretical sensitivity of the researcher which was important during both the data collection and data analysis procedures. The review of the literature is an on-going process because as more was learnt about the case, the researcher obtained a better understanding of the research domain and the literature that was most relevant to the study (Yin, 1989). The following section outlines the case selection process.

3.5. The case selection process

After the initial review of the theory, the process of selecting a suitable case study (e.g., case farmer) was undertaken (Yin, 1994). The aim of the case selection process is to find the richest source of data (e.g., a case farmer) that will inform the research questions. Although it is not necessarily the typical or average case, but the one with the greatest amount of information that is likely to reveal in-depth detail about the phenomenon of interest (Patton, 1990; Yin, 1994, 2002). A randomised sample rarely offers in-depth insight, whereas a meticulously chosen case selected for their validity has the potential to appropriately answer the research questions (Flyvbjerg & Sampson, 2001). The consequence of this purposeful sampling approach to selecting a case, is that the results cannot be generalised to another population, but it can be generalised to theory (Patton, 1987).

The case selection process follows a similar protocol used within empirical farm management studies that have used case study methods with pastoral farmers in New Zealand (e.g., Gray et al., 2008). The case study location of the East Coast (including Gisborne, Hawkes Bay and Wairarapa) was chosen as the researcher resided in the Gisborne region at the time of the research and the hill country farming systems was of interest to the researcher. The case selection process involved approaching an experienced farm management consultant from the Gisborne region to ask if they could identify two to three hill country sheep and beef farmers who they believed were highly resilient and had a high level of adaptive capacity. A description of the characteristics of such farmer were drawn from the literature (Yin, 1989) and provided to the consultant.

The farmer attributes associated with a high level of adaptive capacity included self-efficacy, an internal locus of control, sense-making, strategic thinking, and planning, and lastly the capacity to learn to live with change and uncertainty. Criteria based on these attributed was provided to two farm management consultants on the East Coast, one from the Hawkes Bay and one from the Gisborne region, to use as a guideline to help them identify a suitable farmer. The criteria stipulated that the farmer must: 1) be either an owner-operator, or equity partner of an East Coast hill country sheep and beef farm, 2) be the main decision-maker of the farm business, 3) have large and extended social networks, 4) have a good level of education and farming experience, 5) use a combination of mitigation, adaptation, or innovative strategies on farm in relation to climate change, and 6) have awareness of climate change in the environment. These criteria were used as a guide because the researcher did not have the time to develop a quantitative measure for each of these attributes identified in the literature.

The Hawkes Bay consultant identified two farmers in Central Hawkes Bay and the Gisborne consultant identified one farmer in Northern Hawkes Bay who met the above criteria. The farmers were firstly approached about the study by the consultant to see if they were interested in participating. All three farmers indicated an interest, and their contacts details were then passed onto the researcher via the consultants. Each farmer was approached via a phone call. During the phone call, the purpose of the study and the objectives of the interview were briefly explained to the farmers including the expected amount of time that the interview might take. The farmers were asked if they would consent to a preliminary interview about themselves and their farming operation so that a suitable farmer could be identified for the study. Following verbal consent, a suitable time and date for the interview were agreed upon. The case selection interviews were carried out during July 2022. The duration of each interview was 45 minutes to an hour. One farmer from the Hawkes Bay was unavailable for interviewing due to seasonal demands on farm.

To obtain sufficient information on each of the farmers, the following topic areas from the literature review were used including climate change perception, awareness of a changing climate, social networks, use of information sources, strategic thinking and planning capacity, core capabilities, education, and farming experience (Duranovich, 2015; Eakin et al., 2016; Henriksson et al., 2017; Marshall et al., 2012; Wulansari et al., 2022). Based on these topic areas, a series of structured interview questions were developed (Appendix I) to obtain information about the farmers key capabilities and to provide an understanding of the farmers characteristics. Each farmer in the case selection interviews was asked the exact same questions to maintain validity (Blaikie & Priest, 2019). No exploration of participants responses was undertaken (Yin, 1994, 2002). Additional information about their farming operation was obtained to provide the researcher with background on their farming system (Appendix I).

Following the preliminary case selection interviews with the two East Coast hill country farmers (e.g., Farmer 1 from Central Hawkes Bay and Farmer 2 from Northern Hawkes Bay) that were recommended by each consultant, it was found that both farmers were suitable candidates. Although both were suitable,

Farmer 2 was selected as the main case farmer to inform the research due to him running a traditional hill country breeding operation. In contrast, Farmer 1 was running a traditional operation, but with no breeding stock. Traditional hill country breeding operations are the more typical farming system that is operated on the East Coast of the North Island and thus the findings from such farming system would be more applicable to other East Coast hill country farmers. In addition, the location of the farm is also more applicable to this study as it has previously experienced several shocks (e.g., Cyclone Bola in 1988) and is expected to cope with several impacts such as increased incidence of drought and extreme weather events due to climate change by 2080 (Chappell, 2019; Ministry of Environment, 2017; National Institute of Water and Atmospheric Research, 2020a). The distance of travel to the Farmer 2 in the North Hawkes Bay was also more favourable due to the researcher residing in Gisborne at the time of this research. The following section describes the data collection procedure used in this study.

3.6. The data collection procedure

This section describes how data about the single case farmer was collected for the study. It is separated into three sections. Section 3.6.1. describes the choice of the main data collection techniques for the study. Section 3.6.2. describes how the data collection protocol was designed and Section 3.6.3., describes the interview process.

3.6.1. Choice of data collection techniques

Case study research can involve multiple sources of data collection, which allows the researcher to conduct a broader investigation of the case and prevents subjective bias (Yin, 2014). These sources can include direct data or indirect data (Lopez & Whitehead, 2013). Direct data is generated from verbal or written words, and can include observable body language, and interactions. In contrast, indirect data is typically generated from external sources to the case study, such as documents (Lopez & Whitehead, 2013). Direct data collection is the most common technique used in qualitative research (Eisenhardt & Graebner, 2007; Yin, 2014). The main method for collecting data in a single explorative case study is by face-to-face interviews (Eisenhardt & Graebner, 2007; Lopez & Whitehead, 2013; Yin, 2014). The interview method that is the most appropriate for a case study and of which was used in this study is a semi-structured format (Patton, 1990).

The semi-structured interview format provides the researcher the opportunity to develop a checklist of topic areas that is relevant to the phenomena of interest. The checklist dictates the sequence of questions and the way in which they are asked to conduct an effective interview (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2014). Within a semi-structured interview, it starts with broad warm-up questions and is then followed by more detailed open-ended questions. The participant (e.g., case farmer) will provide a response to the questions and the researcher will listen, and then determine if it is relevant to the research questions and explore further if required using probing questions (Yin, 1994). Semi-structured interviews allow for an open discussion between the researcher and participant, providing the participant with opportunities to

provide additional information into the discussion (Thomas, 2003). The face-to-face interviews were voice recorded to ensure accurate and valid data collection for qualitative research methods and supported by detailed notes (Rosalind & Holland, 2013).

Additional data collection techniques used in the study included a pre-interview questionnaire (e.g., the values exercise and uncertainty survey) (Appendix V & VI). These questionnaires were provided to the participant prior to the final interview to help manage the interview time (Creswell & Poth, 2016). Although questionnaires are typically used in quantitative research, they can be used in a qualitative case study research (Blaikie & Priest, 2019). The questionnaires were designed to provide additional information about the values of the case farmer and their perceptions of future risks. This information was important for understanding the case farmer's characteristics and their adaptation process. Field observations are a common data collection technique used within qualitative research (Yin, 2014). A tour of the farm property was undertaken by the researcher to obtain a better understanding of the context and farm system. This compliments the information obtained within the interviews. Indirect data collection techniques such as documents are also an important source of data (Blaikie & Priest, 2019). Documents such as board meeting minutes would have been useful in relation to the strategic management process used by the case farmer, however, they were not collected from the case farmer.

3.6.2. The design of the data collection protocol

The data collection protocol was designed based on the single case study method framework illustrated in Section 3.3 (Figure 10). The data collection protocol clarifies the subsequent data that will be collected from the single case farmer. The interview schedule includes the purpose of each interview, and the duration of each interview. The design of the data collection protocol drew on the initial review of the theory and various research method texts, which focus on case study data collection and social science research (e.g., Blaikie & Priest, 2019; Patton, 1990; Thomas, 2003; Yin, 2014). To capture the case farmer's adaptation process, a checklist of relevant topics was developed from the literature. The checklist below provides a brief overview of the key topic areas, with a more detailed checklist provided in Appendix VII.

- Vision, values, and goals (including personal and farm business)
- Adaptation process (all stages)
  - Scanning the environment for cues of change in relation to climate change
  - Identifying a change in the operating environment
  - Assessing the impact and nature of a change on their farm system
  - Formulation of a suite of strategies and associated tactics to adapt to change
  - Implementing strategy to adapt to change
  - Monitoring and evaluating of the implemented strategy to enhance learning and build capacity

Three interviews were undertaken to capture sufficient information about the case farmer's adaptation process to answer the research question and achieve the research objectives set out in Section 1.3 and 1.4., respectively. The first two interviews with the case farmer focused on obtaining relevant information about the farmer's perception of climate change and the opportunities and threats within their operating environment that may impact their farm system. The final interview aimed to capture each stage of the adaptation process and explore each stage in detail. Each of the three interviews ranged from 1 hour to 1 ½ hour. Prior to the final interview, the case farmer was provided with the values exercise and the uncertainty survey (including the arrow of attention exercise) (Appendix V & VI). These were emailed to the case farmer in March 2023 for voluntary completion. The exercise and survey were explicitly used to 1) determine the values, goals and strategic intent of the participant and their farm business (Appendix V) and 2) to identify the specific opportunities or threats to the farm business, as well as the likelihood of them happening (Appendix VI). The following section describes the interview process.

3.6.3. The interview process

The process used for all three interviews followed a similar procedure. The first step of the interview process was to contact the case farmer via a phone call to introduce the researcher and explain the purpose and objectives of the study and explain the interview process (Perecman & Curran, 2006). The farmer was asked if they would consent to 2-3 interviews ranging from 1 hour to 1 ½ hour to obtain information about their farm system and their climate change adaptation process (Burns, 2000; Olson, 2011). Following verbal consent, a suitable time and date for the interview was arranged, with the farmer given priority of availability (Olson, 2011). The interviews were carried out during September 2022 to April 2023. For the first interview, upon arrival at the case farmer's place of residence, the researcher briefly introduced themselves and began talking about light topics that might be of interest to the participant to build rapport. This was to ensure the participant and researcher were communicating in an open manner to develop effective engagement throughout the interview to obtain meaningful information (Perecman, & Curran, 2006). Once seated and the environment felt comfortable and relaxed, the interviewee was given an information sheet (Appendix III) to read thoroughly and a consent form (Appendix IV) to read and sign, accordingly. More detailed information on the use of the information sheet and consent form are provided in Section 3. 7.

The structure of the interviews follows a similar structure to that set out in the checklist of topics (Section 3.6.2. & Appendix VII), whereby it dictates the sequence of the questions and the way they are explored with the participant (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2014). During the interview there were different question types that were used to extract information from the participant about their adaptation process. At the beginning of the interview, broader and closed questions were used to ensure the participant was comfortable and allowed them to engage in the discussion freely (Adams, 2015; Yin, 2014). Closed questions are then followed by detailed open questions which are tailored to the case study (Adams 2015). The use of probing questions later in the interview helped to explore areas of a specific topic where in-depth

detail was required by the researcher (Yin, 2014). If responses from the participant were not clear, the researcher asked for clarification to ensure the participants responses were understood. This reduced the likelihood of misinterpreting the farmer's responses (Eisenhardt, 1989; Yin, 1994).

Each interview was voice recorded using a mobile phone device (Olson, 2011). The recording device was checked prior to the beginning of each interview to ensure adequate battery level and that the recording device was operating correctly. The device was monitored during the interview to ensure it was recording correctly. At the end of the interview, the recording device remained on for another 10 to 15 minutes to capture any additional information added by the participant. Permission was obtained verbally to include this information as data (Olson, 2011). Once the recording was stopped, the audio file was saved to the mobile device. The voice recordings were backed-up and transferred to a USB stick to protect the data and avoid any potential loss of the data (Olson, 2011). Each interview was finished up by acknowledging the participants time and effort to assist the researcher in the study. For subsequent interviews, the participant was contacted to arrange a suitable date and time for any follow up interviews. Summaries of the interviews were provided to the case farmer to verify, where the participant had the right to correct inaccurate information. This task was carried out to ensure the researcher did not mis-interpret information about the farm system and the case farmer's adaptation process (Blaikie & Priest, 2019). The following section describes the data analysis procedure.

3.7. The data analysis procedure

The data analysis procedure used for this explorative single case study used the qualitative data analysis (QDA) technique to convert raw data derived from the interview transcripts into a case report to then compares it back with the literature. This section draws on the QDA methods developed by Dey (1993), Miles and Huberman (1994) and Corbin and Strauss (2008). The qualitative data analysis technique was used to achieve the objectives set out in Section 1.4.

Drawing from the qualitative data analysis techniques developed by Dey (1993), the qualitative data analysis process is described as an iterative cyclical process that comprises of three stages: 1) describing, 2) classifying, and 3) connecting. The QDA processes described by Miles and Huberman (1994) and Corbin and Strauss (2008) is like that of Dey (1993) where descriptive data is coded to identify important concepts and relationships, and then synthesised into a case report that describes the richness of the phenomena (Dey, 1993). In the first phase of Dey's (1993) process, the data from a transcript is described to maintain the holism of the data (Dey, 1993). In the second phase, the data in the transcript is classified or coded to identify the important concepts relevant to the phenomena of interest (the case farmer's adaptation process) (Dey, 1993). In the third phase, relationships between categories or concepts are identified in the data and used to develop a model of the phenomena of interest (Dey, 1993). This cyclical process is repeated, and the analysis us refined until the researcher reaches closure (Dey, 1993). The researcher decided to conduct this

analysis informally and documented the results using Microsoft Word as text and tables rather than formal QDA software such as NVivo. This choice was made because of the time required to learn how to use the software and because the researcher had experience in analysing qualitative data informally using Microsoft Word text and tables.

For the describing phase (Dey, 1993), within a week of each interview, the data from the voice recordings were transcribed using Microsoft Word. Transcripts were thoroughly read and reviewed to correct any errors. Each transcript was summarised, and additional notes were made with some initial grouping and categorisation of the data (Dey, 1993; Miles & Huberman, 1994). The supporting notes taken during each interview were also reviewed and described in detail.

During the describing stage, the first interview transcript was chosen, read, and then a written description of its content was developed to describe the phenomena of interest (Dey, 1993). The description provides an overview of the raw data and highlights important aspects to maintain the holism of the data (Dey, 1993; Miles & Huberman, 1994). The description process was guided by the research question and informed by the literature review which the researcher thoroughly read to ensure they were sensitized to the data (Dey, 1993). Some initial concepts were drawn from the description using the literature review as guidance for concepts that were suitable. Often concepts were initially identified in the data, but when similar concepts were found in the literature review, they were reworded for better representation, that is, terms used by the farmer were translated into the terms used to describe concepts from the literature (Dey, 1993; Miles & Huberman, 1994). In the initial description, some concepts were named, and a description of relevant relationships was developed (Dey, 1993). As the researcher iterated through the QDA process, additional concepts and relationships were added to the description from the classification and connection stages (Dey, 1993). Once the first interview was analysed, the process was repeated with the remaining interviews. A case description including a description of the farmer, the farm system, and its physical and financial performance was also developed to provide understanding of the case from a theoretical perspective (Dey, 1993). Once the initial description was written, the next stage was the classification stage (Dey, 1993), where the data from the transcript was coded (Corbin & Strauss, 2008; Dey, 1993; Miles & Huberman, 1994).

The second stage of 'classifying' involves coding the data into categories relevant to the research focus (Corbin & Strauss, 2008; Dey, 1993). The first step involves reading through the literature review to become familiarised with the relevant theory, and identify important concepts and their definitions (Dey, 1993; Miles & Huberman, 1994). The description was read to identify concepts that were identified during the describing stage. The interview transcript was then read line-by-line to compare the data to existing concept definitions. Data-bits within the transcript (e.g., single word, several words, an entire sentence, several sentences, or a paragraph) were extracted to define a piece of text that is an example of a category (Dey, 1993). The definitions that define a category place a boundary around the original concept and enables one concept to be specific and distinguishable from another when allocating data-bits (Dey, 1993). If a data-bit matches a

definition of a category, it was then classified as an example of that category. If it did not fit within the boundary of an existing category but was relevant to the study and not reported in the literature, a new category was developed using a self-explanatory name and definition (Dey, 1993).

Once the data was analysed and categories were identified, the categories were placed into a logical hierarchy using the "is a" rule to determine a categories location in the hierarchy (Dey, 1993). The categories were placed into a category hierarchy of supra and sub-categories to show the logical relationships between categories. During this process, some categories were split when the researcher found that data-bits within a category were able to be sub-divided into sub-categories that were more theoretically useful (Dey, 1993). Once the researcher had collated all the appropriate data-bits associated with a category, they used the comparative method to identify similarities or differences (Dey, 1993). If theoretical distinctions were made, the sub-categories were named and defined. Categories were also spliced were appropriate to combine a higher-level category with sub-categories to be more theoretically useful (Dey, 1993). The classification process of coding the data was carried out manually using Microsoft Word and placing the categories into a table that showed the category name, location withing the logical hierarchy, its definition and the data bits or evidence to show it existed in the data (Corbin & Strauss, 2008). During the classification process, the data was read thoroughly, to identify lines of text that relate to a category. The text was copied and pasted into a table that included relevant information such as the name of the category, and placed in the category hierarchy, the definition of the category, the data-bits, the case, and the interview transcript and line number from which each data-bit comes from (Dey, 1993; Miles & Hubermann, 1994).

Once the category hierarchy was developed, the next step in the QDA process is 'connecting' (Corbin & Strauss, 2008; Dey, 1993; Miles & Huberman, 1994). This involves recognising and identifying the causal (cause and effect), explanatory or chronological relationships that exist in the data (Dey 1993). The most common relationships found in the data were chronological and explanatory relationships. A chronological relationship shows the actions the individual undertakes through time, or the sequence of activities such as those used by the case farmer in his adaptation process (Dey, 1993). These were normally identified using conjunctions such as: "I do X and then I do Y" or after doing X, I undertake Y". An explanatory relationship is an explanation of why the individual undertakes such activities (Dey, 1993). These relationships were important for understanding the reasons behind the activities the case farmer undertook within his adaptation process. The explanatory relationships were normally identified using conjunctions such as: "I do X in order to achieve Y", or "Y is achieved by undertaking X" (chronological relationship). The data-bits from the linkages were copied and pasted into tables to be classified under the appropriate relationships and defined. Once the linkages were identified, the researcher then drew them into a series of diagrams to model the identified linkages and over time develop a model of the case farmer's adaptation process (Dey, 1993).

Once the first cycle of the QDA was carried out, it was then repeated several times until no more refinements could be made and closure was reached (Dey, 1993). The initial description undertook iterations of

refinement after each additional analysis cycle to best describe the phenomena of interest until no more refinements could be made. The final description became the case report for the study. The final case report was then formally compared with the relevant literature in the discussion chapter to identify similarities and differences. If similarities were found between the case report and the literature, this provided support for the existing theory. If differences were identified, the theory was modified to appropriately represent these findings, such as the addition of new concepts or relationships to the existing theory (Corbin & Strauss, 2008; Dey, 1993; Miles & Huberman, 1994).

3.8. Ethical considerations

The main ethical issues identified for this explorative case study were around maintaining privacy, confidentially and autonomy. These ethical issues and how best to manage them were discussed with the supervisory team prior to submitting a low-risk notification. A low-risk notification for ethical approval was submitted on 11/07/2022 to the Massey University Human Ethics Committee. Correspondence was received to acknowledge receipt of the notification and its entry onto the database. The research was approved to go ahead.

Following the ethics application, each participant was contacted via a phone call to request participation in a selection process interview. During this phone call, the researcher was introduced, and the purpose of the study and the objectives of the case selection interview were briefly explained to the participants. The expected amount of time that the interview may take was clarified. The participants were asked if they would consent to a preliminary selection interview. Following verbal consent, a suitable time and date for the interview was arranged, with the farmer given priority of availability (Olson, 2011). The researcher ensured the participant that they could decline participation if they wish, as it was voluntary. A similar process of contact was used when the case farmer was selected for the research process interviews. Once the single case farmer was selected it was reiterated that they were not obligated to continue with the study and, if they wished could withdraw at any time. The researcher asked the participant prior to each subsequent interview if they were willing to participant to confirm ongoing consent (Burns, 2000; Olson, 2011).

On arrival at the interview, an information sheet was provided to the participant to read. It explained the purpose of the research and interview objectives, its procedure, its risks, and any concerns. It provided necessary contacts and outlined the participants involvement, the benefits of this research and their right to withdraw from the study (Appendix II & III). After reading the information sheet, the participant had the opportunity to ask questions, and these were answered by the researcher. This ensured the participant was fully informed of their involvement in the research, prior to beginning the interview (Olson, 2011). Additional information sheets were provided to the participant throughout the study, where necessary. A consent form was provided to the participant (Appendix IV) to read and sign, accordingly. The purpose of the consent form was to ensure that the participant understood their involvement, consented to participating

in the study, and that they were comfortable with each interview being voice recorded. Once the participant signed the consent form, permission to voice record was obtained and the interview could progress (Burns, 2000; Olson, 2011). The researcher reiterated the importance of the participants freedom to decline answering any questions during the interview and if they wished to have the audio recording paused at any time during the interview (Olson, 2011). Privacy and confidently of the information (including sensitive and personal information) was always ensured. The participant (e.g., case farmer) was assured that they would not be referred to by their real names in any publications. Any personal information was securely stored entirely separate from data. Given that the case report, map, and some information relating to the equity partnership and merged property are mentioned in the study, the case farmer could be identified. However, the case farmer consented to this being published and hence such information (identifying features) was not removed.

Chapter Four

4. Case description

4.1. Introduction

This chapter sets out the background information on the case farmer and family farm as well as an overview of the farm business and how it operates as an equity partnership. Section 4.2., provides a brief description of the case farmer and the family farm background, followed by Section 4.3., which provides an overview of the case farm business and equity partnership. Section 4.4., highlights the farm vision, and values and goals of the farm business and those in relation to the case farmer. Section 4.5., describes the case farmer's attitude towards different values. Section 4.6., describes the threats and opportunities the case farmer perceives to be important and their likelihood occurrence, followed by Section 4.7., which provides a description of the key resources on-farm (e.g., land, labour, and capital). Section 4.8., describes the main farming policies of the farm enterprise and provides a description of the sheep and beef cattle enterprises, and the forestry enterprise on the farm. The final Section (4.9) provides an overview of the physical and financial performance of the farm system,

4.2. The background of the case farmer and farm family

The case farmer is a second-generation hill country sheep and beef farmer in the Northern Hawkes Bay region of the North Island, New Zealand. He originally grew up in the local area, on a neighbouring farm to the current farm that he owns in an equity partnership. After completing secondary school education, he attended the Cadet Training farm at Smedley Station in Central Hawkes Bay, where he undertook a two-year farm cadetship. The cadetship provided him with formalised training, which consisted of practical and theoretical components. He received the equivalent of a Certificate in Agriculture Level 3 and 4 upon completion. After his cadetship, he attended Lincoln University in Lincoln, Christchurch where he gained a bachelor's degree in Agricultural Science.

Following his tertiary education, he chose to follow his passion in the sheep and beef sector and began shepherding in the early years of his farming career. Through his farming career he has progressed through different on-farm roles, gaining experience in a variety of different roles which offered different levels of responsibility, including a role as a stock manager. He has around 25 years of farming experience in the sheep and beef sector. He has been the managing director of the case farm for which this study focuses on for the past 12 years. He has a strong interest in dryland farming practices, that he developed whilst studying at Lincoln University and applies both his practical on-farm experience and university education into managing the current property. He and his family including his wife and children live on-farm, however the family is

not significantly involved in the day-to-day operations of the farm business. The following section provides an overview of the farm business.

4.3. Farm business- Equity partnership

The farm business is a New Zealand registered company and is operated under an equity partnership (Figure 11). The equity partnership consists of the case farmer who is the managing director of the farm and the other equity partner. The ownership ratio is 30/70, respectively between the case farmer and his equity partner. The equity partnership was formed in 2011 by combining two adjacent properties. The original station property was 820 hectares and consisted of a 50:50 sheep and beef cattle breeding and finishing operation. The other property, consisting of 460 hectares of breeding country was merged with the original station to establish the current property (e.g., case farm). Following the combination of the two properties, less trading stock was brought in as the new property had a larger proportion of suitable breeding country and was able to breed all the stock that was required for finishing.

The governance of the equity partnership involves a board of three directors. The directors comprise of the case farmer, the other equity partner, and recently the son of the second equity partner (Figure 11) has been added to the board. This addition is part of a succession plan by the second equity partner. The son brings in rural banking expertise, providing regular market updates and market forecasting. The second equity partner and son live locally within the Gisborne region.

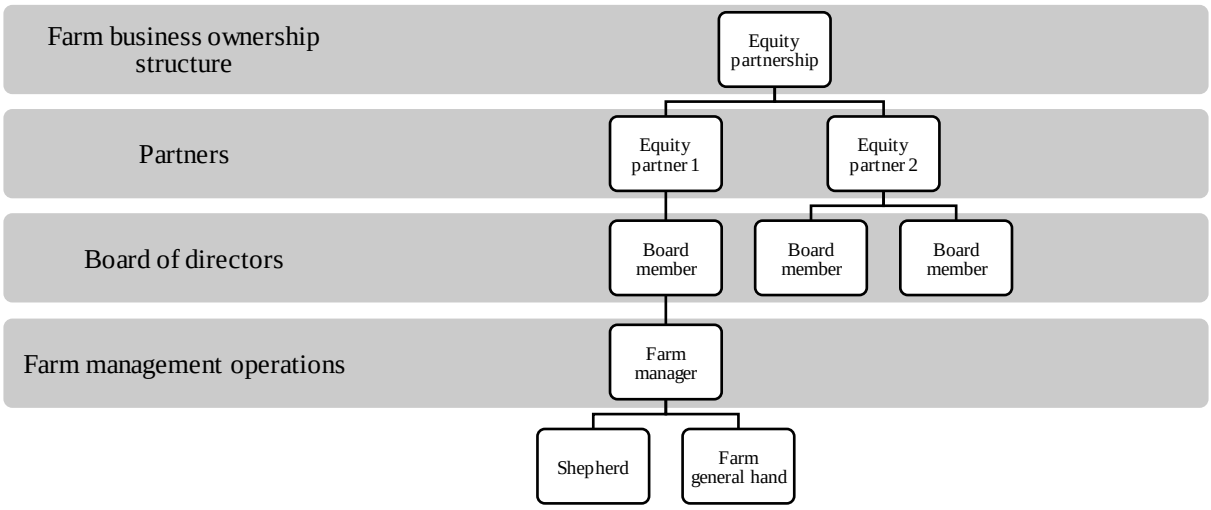

Figure 11 The ownership and farm management structure typology of the case farm.

The board has a governance role within the farm business and the strategic decisions, are discussed and mutually agreed upon by the directors prior to implementation. The case farmer is the managing director on-farm and his role in the farm business is the main on-farm decision maker for operational, and tactical decisions. He oversees the tactical and day-to-day operations of the farm system. The case farmer has the role of farm manger, and he is also in charge of the shepherd and farm general hand. Board meetings are held

every month, or two months. During each board meeting, minutes are written up about the discussions and retained in the farm records. The farm accountant is independent from the board of directors and is not associated with the governance of the partnership. The accountants role is to oversee the financial integrity of the farm business and assist with financial analysis and provide financial advice where appropriate. The following section provides an overview of the farm business vision, values, and goals, including those in relation to the case farmer.

4.4. Vision, values, and goals

The main vision statement that both equity partners have identified is "*To consistently make a reasonable return from the farming system to ensure the farm business operates efficiently and continues to grow and progress towards being resilient and future proof".* Drawing from the vision statement the main aim of the farm business is to operate a hill country sheep and beef cattle farm that provides:

1) Financial success through farming the property to its optimal potential, maintaining a good level of stock condition and preparing stock (e.g., sheep and beef cattle) in an appropriate manner to meet high-quality standards that provides the farmer with fulfilment and overall satisfaction of his management ability.
2) A rate of business growth that ensures:
    a. Each equity partner and their families' ideas and values are taken into consideration to ensure pride of ownership is retained.
    b. Income which is safeguarded for the future to ensure each equity partner has a comfortable retirement from farming and the next generation have an equal opportunity to farm.
3) The ability for ongoing incremental change in the farm business to allow for business growth at each equity partners own pace and the overall affordability of the farm business.
4) An on-farm environment that allows for the enjoyment of hill country sheep and beef farming to be preserved through the acquisition of purposeful on-farm activities that creates value and a meaningful lifestyle to those involved. The farm operation will endeavour to maintain good relations with employees and create congenial farm working conditions that are supportive, safe, sensible and provide income security. Above all, the farm will provide an environment for personal growth and the expression of pride in one's own work.

The case farmer has suggested that the goals and values play an important role in the farm business and are the major driving force of the operation. He strives to achieve profitability and success every day, *"That's what we strive for every day, to make money so we can spend the money"* to progress towards future proofing their farm system and adding meaningful value to their farming journey. The following section describes the case farmer's attitude towards different values.

4.5. Values Exercise

A values-based exercise based on the work of Gasson (2008) (Appendix V) was used to assess the case farmer's values. Such exercise showed that in terms of importance (one being the least important and five being the most important), the values that relate most to the case farmer, and thus hold the most significance to him is the expressive values which ranked the highest (3.8). This is followed by business values (3.6), lifestyle values (2.8) and the lowest ranked being the social values set (2.6). The average scores of the four value sets have been plotted on a spider graph (Figure 12) to illustrate the importance that the case farmer places on each value set.

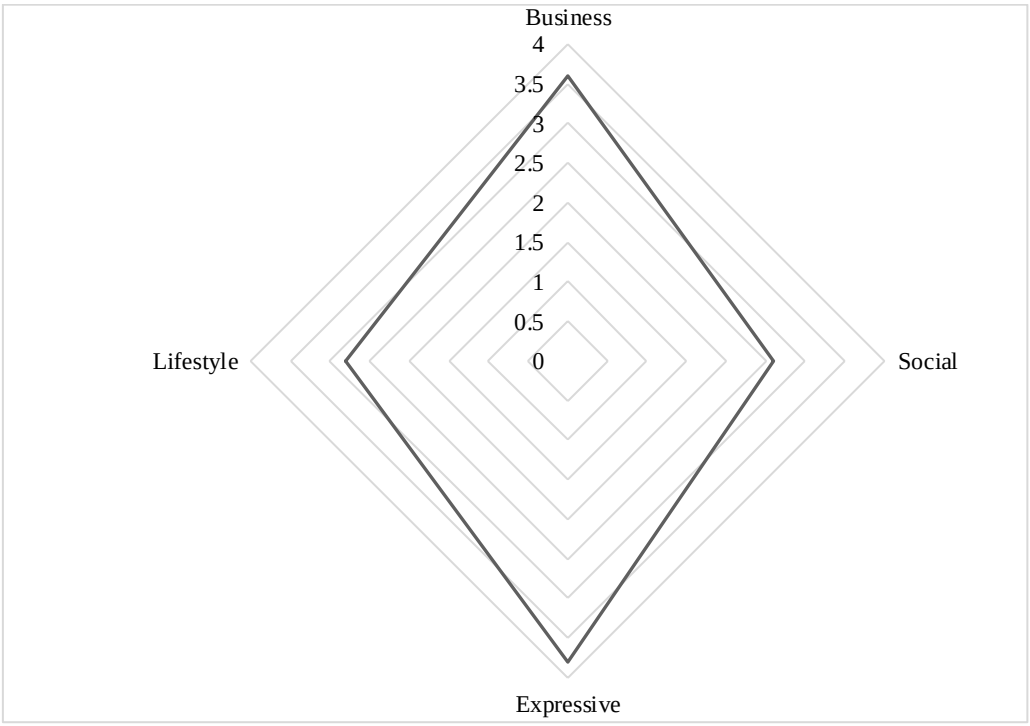

Figure 12 Spider graph illustrating the average score of the four key value sets (business, social, expressive and lifestyle) ranked by the case farmer.

Gasson's (2008) describes four key value sets (business, social, expressive, and lifestyle). The *business values* relate to where farming is viewed as a means of obtaining income and security with pleasant working conditions. *Social values* are where farming is undertaken for the sake of interpersonal relationships in work. *Expressive values* are where farming is a means of self-expression or personal fulfilment, and lastly *lifestyle values* is where farming is valued as an activity (Gasson, 2008). Based on the case farmer's ranking, the expressive value set was ranked the highest. This suggests he finds a deep sense of value in farming in a way that allows for self-expression in relation to what he is most passionate about (e.g., hill country sheep and beef farming) and enables him to fulfil personal goals within his farming career. In addition, as business values were ranked the second most important this demonstrates he values maintaining a viable farm business, in terms of obtaining an income from the sheep and beef cattle operation and working in an environment that is outdoors and with animals. The lower ranked value sets (social and lifestyle) are

important to a degree. However, such values are not emphasised as much in the day-to-day life of his farm business. Individual ranking of each particular value is detailed in Appendix VIII. The following section outlines the key opportunities and threats to the farm business based on the Uncertainty survey and Arrow of Attention exercise.

4.6. Uncertainty Survey and Arrow of Attention

Drawing from the Uncertainty Survey and Arrow of Attention exercise that the case farmer completed (Appendix IX), Figure 14 illustrates the "Arrow of Attention" that contains what the case farmer believes are the most important opportunities and threats in his operating environment over the next 5-10 years. The important threats and opportunities are those that the farmer thinks will have a high impact (positive or negative) on the business and of which have a high likelihood of occurring.

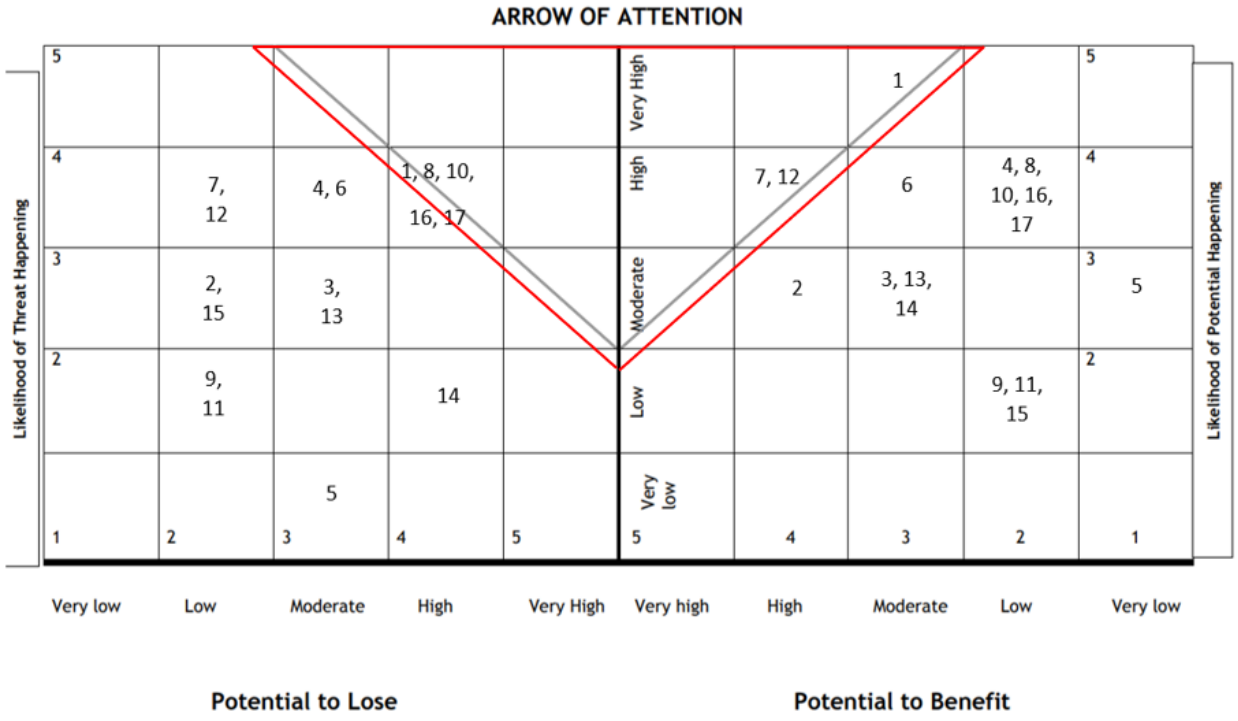

Figure 13 Arrow of Attention exercise which illustrates the position of each uncertainty over the next 5-10 years according to the case farmer's perception of the potential to lose or benefit and the likelihood of it happening.

The most important threats identified by the case farmer include: (1) climate variation, (8) product and inputs prices, (10) supply chains to market, (16) government laws and policies, and lastly (17) local body laws and policies. These sources of uncertainty were scored as having a high potential to lose and a high likelihood of the threat happening (Figure 13).

In contrast to his important threats, the important opportunities the case farmer has identified that he expects to face over the next 5-10 years includes: (1) climate variation, (7) global demand for farm products and lastly (12) technology (Figure 14). Climate variation was scored by the case farmer as having a moderate

potential to benefit and a very high likelihood of the opportunity happening. The opportunities of global demand for farm products and technology were both scored by the case farmer as having a high potential to benefit and a high likelihood of the opportunity happening. The case farmer identified no 'black swans' on Figure 14. A black swan is a source of uncertainty that is likely to have a very high impact on the farm business but is highly unlikely to happen.

An important finding within the Arrow of Attention exercise is that the case farmer recognised that the source of uncertainty known as 'climate variation' has both an upside (potential to benefit) and a downside (potential to lose) risk. This suggests that the case farmer is aware of the opportunities and threats that are associated with this source of uncertainty and therefore is likely to strategically position the farm business to minimise the influence that climate variation has on the productivity and profitability of the farm system as well as take advantage of the opportunities that climate variation has on the farm system. The case farmer gave climate variation a greater score of four in terms of the downside risk in comparison to the lower score of three in terms of the upside risk. Thus, suggesting that the downside risk of climate variation may present a greater threat to the case farmer's farm business than the opportunities that arise from such risk.

Climate variation is a source of uncertainty that is important in relation to climate change, whereby climate change is expected to increase the level of climatic variability on the East Coast of the North Island, New Zealand (Mullan et al., 2008). The case farmer is concerned about the influence and thus the direct impact that climate variation has on pasture production, which in turn influence his productivity and profitability. The case farmer is concerned about drought, as traditionally the East Coast of the North Island is considered a summer dryland environment. However, in terms of the positives, the climate on-farm has become more favourable due to observed changes regarding warmer winters and moister summers over the last 10 years. This to some degree may have influenced his scores as such. The following section provides a description of the on-farm resources.

4.7. Farm resources

The following section outlines the farm resources of the property including the land (physical), labour and capital. Section 5.7.1., describes the land resources and this is followed by Section 5.7.2., which describes the labour resources. The final section (5.7.3) describes the capital resources.

4.7.1. Land

The farm is located 34km east of the Wairoa township in the Hawkes Bay region on the East Coast of the North Island, New Zealand (Figure 14). The farm is approximately 5km inland from the coast. The farm business is operated as an equity partnership comprising of two farming families, with one of the partners being the farm managing director. The property is 1100 effective hectares (ha), with 1280 hectares of total farm area. The Hawkes Bay region, particularly the Wairoa district is subject to a temperate climate with long, dry summers and moderate winters (Chappell, 2019b). The orography particularly the Huiarau

mountain ranges in the west influence the predominant westerly winds and result in high summer temperatures with dry conditions. Much of the rainfall in the Hawkes Bay/Wairoa district is a result of easterly or southerly winds, which produce highly variable and sporadic rainfall, particularly during the spring and summer. The Wairoa district has an average rainfall of 1200mm/annum and an average daily temperature of 10° C (Chappell, 2019b). Since the formation of the equity partnership the average rainfall has been 1500mm/annum and can range from 1100-2000mm/annum in any given year, with significant differences in the level of precipitation occurring across the property.

Figure 14 Map of the Hawkes Bay Region of the North Island, New Zealand (Adapted from Chappell, 2019b).

The property has a good fertiliser history with a pH of 5.6 to 6.0 and an Olsen P of 30 on the flats and an Olsen P of 10-20 on the rolling to steep hill country. Soil types on the property are alluvial silt on the flat country and sedimentary sandstone-based soils on the hill country. The fertiliser program is a priority to maintain soil fertility for pasture production. Generally, 6.0 t/ha of lime is applied to the fodder beet paddocks 12 months in advance of the sowing date. The flat country has received 3.0 t/ha of lime over the last 10 years and the hill country receives 1.0 t/ha only when required as maintenance. Superphosphate is the main fertiliser that is applied annually to most of the property. The application rates differ across the different slope classes but are usually maintenance plus level of fertiliser is applied, with 300-350 kg/ha of superphosphate applied on the flat country and 250 kg/ha of superphosphate applied on the hill county. Generally, the farm manager aims to apply 30 units of phosphate (P)/ha on the flat country and 20-25 units

of P/ha is applied on the hill country. Fertiliser and lime applications are tailored to suit the soils tests, which are carried out every two years.

The property has mixture of north and south facing slopes. The farm comprises of 100 hectares of productive flats, 100 hectares of developed and cultivated rolling country and 900 hectares (50:50) of medium to steep hill country. A further 120 hectares has been retired from grazing and has been planted in radiata pine. The altitude of the farm ranges from 10m asl (above sea level) on the flat country to 220m asl at the highest point. The vegetation on the farm includes a mix of high-quality pastures such as ryegrass and white clover, and a mixture of cocksfoot, and subterranean and red clover, on the flat and rolling country. The moderate to low fertility pastures include brown top, rats tail and kikuyu which are predominately on the hill country. Alternative pasture species include chicory and annual ryegrass as well as fodder beet for winter forage. There are also several poplar plantings on the moderate to steep hill country in in various areas for land stabilisation and erosion control as well as to provide shelter for grazing stock. Annual poplar planting of approximately 150 poplar poles is undertaken to minimise erosion on hill country. There are existing vegetation pockets of native manuka and kanuka scrub situated across the property. The main weed species on the property include nodding thistles, ragwort, and blackberry. The main pests include goats, rabbits, and hares. The main diseases on-farm that impact animal health and production include internal parasites and facial eczema.

4.7.2. Labour

The farm operation employs three full time employees including the farm manager (case farmer), a shepherd and a farm general. The main role of the farm manager is to oversee the day-to-day running of the farm operation and typically make all tactical and operational decisions on farm. The shepherd and farm general assist with the day-to-day operations of the farm, including mustering, stock movements, break-fencing, drenching, docking/tailing, crutching, feeding-out, general repairs and maintenance (incl. fencing). Extra labour units (e.g., casuals farm hands) are sometimes employed and used during docking/tailing when there is a requirement for extra staff to assist the main labour units. A local contract shearing gang is used for shearing the ewe-flock, hoggets and lambs.

4.7.3. Capital

The farm is classified as a Class 4 North Island hill country sheep and beef farm. The farm winters a 4000 Romney-Coopworth ewe flock, 1250 ewe hoggets, 60 rams, and 325 breeding cows. Additional stock including 175 R1yr heifers, 130 R2yr heifers, 250-300 R1yr bulls, 250-300 R2yr bulls and 14 MA breeding bulls are also wintered on-farm. The breeding cow herds are a mix of purebred Angus and Hereford cattle that are separated into two mobs. The main pasture types on-farm are perennial ryegrass and white clover on the flat and rolling hill country, with a mixture of brown top, rats tail and kikuyu on the rolling to steep country. Previously 100 ha has been developed and sown with a mixture of cocksfoot, subterranean, and red

clover for drought persistence. Further development of rolling country is expected to occur, to eliminate lower quality pasture species and this will be re-grassed with cocksfoot, subterranean, and red clover. For summer forage, 20-30ha of chicory is grown as well as 20-30ha of annual ryegrass (e.g., Italian ryegrass/moata) on a mix of flat and rolling country. Chicory is utilised by the ewe hoggets, lambs, and the ewe flock during the year. For winter forage, 5-6 ha of fodder beet is sown each year and utilised for wintering beef cattle male progeny.

The farm is subdivided into approximately 100 paddocks of varying size and contour. There is one major gravel track (e.g., driveway) from the road to the main sheep yards and woolshed for stock truck access. There are various on-farm tracks which range from accessible by four-wheel drive and/or farm vehicles to those accessible only on-foot or horseback. The main farm infrastructure buildings include, two houses, a centrally located 5-stand woolshed with large, covered yards that can hold up to 1500 head of sheep, one implement shed, cattle yards and numerous satellite yards of varying quality and capacity to hold sheep and cattle. These are strategically placed throughout the farm for ease of mustering and operational tasks such as docking and drenching. There is also an airstrip located on the flat country and a fertiliser bin which is used for top-dressing. The farm has around 60 ha of tile drainage situated on the flat country, which has been largely put in place to accommodate previous drainage issues. The water supply on-farm comes from a stream which flows through the property. The water supply is reliable with a new reticulated water system implemented on-farm with multiple water tanks that reticulate water across the property. There is no irrigation on the property. The key plant and machinery (incl. vehicles) include a tractor with feed out wagon, ute, side-by-side and two quad bikes. Supplementary feed on hand in the average year includes 120 tonnes of maize silage, which is grown and made on-farm when required. Around 20-50 bales of baleage are made on-farm and stored for use in winter or summer when pasture supply is low or used for transitioning beef cattle onto the fodder beet. The next section outlines the enterprises on the farm and details provides key information about the stocking policies and their management.

4.8. The farm business enterprises

The following section outlines the three main enterprises of the farm business. The first two enterprises are the sheep and the beef cattle enterprise, whereby each account for 50% of the total stock units on the property, respectively. The final enterprise on the farm business is the carbon credit forestry enterprise Section 4.8.1., provides a description of the sheep enterprise, followed by Section 4.8.2., which provides a description of the beef cattle enterprise. The final section (4.8.3) provides a description of the forestry enterprise.

4.8.1. The sheep enterprise

The sheep enterprise comprises a 4000 head Romney-Coopworth ewe flock including 1250 ewe hoggets, and 60 rams. Of the 4000-ewes, 1000 are in the B flock which consists of 5-year (5T) ewes and any ewes deemed

not fit to breed replacement ewe-lambs from. These are mated to a terminal sire (Charollais). The terminal flock (B flock of 1000 ewes) are mated in late February, with the rams going in on the 18th of February and lamb in mid-July. They are then weaned late October and early November. The mixed age (MA) ewes and two tooths (2T) are mated in late March to early April and begin lambing in mid to late August, with a mean lambing date of around the 1st of September, they are weaned early December. Depending on pasture supply at the time of mating, the decision to mate the ewe hoggets will be made. In the case that pasture supply is adequate, the ewe hoggets (1250) are mated in early May and their planned start of lambing is 1st October. They are weaned early January. The ewe flock lambing percentage is 145-150% and the ewe hoggets lambing percentage is typically 80-90% with an average of 85% lambing. Around 1000-1250 ewe hogget replacements are retained each year.

The Romney-Coopworth ewe flock produces 30,000 to 35,000 kg of greasy wool per annum (4.5-5.3kg wool/SSU). Shearing is generally carried out at 6-monthly intervals. The lambs are shorn in January. The ewe hoggets are shorn in late July and then late February, prior to being a two tooth. The two tooth ewes (1000) with lambs at foot are shorn in early November. The terminal flock is shorn in late October or early November and the MA ewes (2000) are shorn in mid-December. The MA ewes including the terminal flock are generally shorn after mating, with the terminal flock shorn in late April or early May and the MA ewes shorn in late May or early June. The ewe flock has been bred to have high facial eczema (FE) tolerance. The selection of high FE tolerant rams which have high DPX (Dual Purpose) and NZMW+X (NZ Maternal Worth index) indexes specific to FE continues to strengthen the FE tolerance of the ewe flock. The sheep policy aims to sell most lambs as prime at a carcase weight of 18kg to the local abattoir before March. As sheep performance has improved and hogget mating has been undertaken, some store lambs are now being sold depending on the season. Generally, around 1000 store lambs will be sold at 36-38kg liveweight. Cull ewes are sold when required.

4.8.2. The beef cattle enterprise

The beef cattle enterprise comprises of 325 mixed age (MA) breeding cows that comprise of two separate herds of 200 Angus and 125 Hereford cows. The breeding cows' planned start of calving is in early September and usually calve amongst the MA ewe flock. Calves are normally weaned and tagged in late February or early March, prior to the MA cows being pregnancy scanned a week later. The farmer does not mate his R1yr heifers, preferring to mate as R2yr heifers to calve as R3yr heifers in late August. The breeding MA cows including the R3yr heifers calving rate is between 94-98%. Mating starts for the R2yr heifers on the 7th of November, and the 7th of December for the MA cows and is carried out over approximately 50 days (Approx 2 to 2.5 cycles). Mating is natural with the use of short gestation Angus and Hereford bulls to reduce late calvers in the herd. A comprehensive bovine viral diarrhoea (BVD) programme is used for the beef cattle enterprise. This involves regular screening (blood testing) and the use of vaccination as a preventative tool to reduce potential BVD infection.

The farm also winters approximately 175 R1yr heifers, 130 R2yr heifers, 250-300 R1yr bulls, 250-300 R2yr bulls and 14 MA breeding bulls. All male bull progeny are wintered on a fodder beet crop from June through to early September for approximately 100 days, while the MA cows and heifers are wintered on grass. The selling policy for the beef enterprise is to finish and sell all surplus progeny (typically bulls) prime at 24-30 months of age at carcase weights ranging from a minimum of 300 kg up to 350 kg. The aim is to sell a proportion of the R2yr bulls to the dairy industry around the first week of November (up to 200 in a good year). A further 100 to 150 R2yr bulls may also be purchased in April or May and grown throughout the winter and sold prime at a carcase weight of 330kg in November.

4.8.3. The forestry enterprise

The forestry enterprise comprises of 120 hectares of radiata pine (*Pinus radiata*). The land that has been used for this enterprise, was converted from grazing was severely underdeveloped, prone to slips and soil erosion. The pasture on this country was predominately low fertility pasture species (e.g., browntop) that produced a limited amount of low-quality feed over the year. Given the nature of the pasture and the erosion problem, this steeper country, was retired from grazing, and planted in radiata pine in 2019/2020. The forestry was planted under the He Waka eke Noa - The Primary Sector Climate Action Partnership to gain carbon credits under the Emissions Trading Scheme set up in New Zealand. It was initially developed with the aim to diversify the farm's income streams. Income from carbon credits would supplement income from the sheep and beef enterprise. The following section describes the physical and financial performance of the farm business.

4.9. The physical and financial performance of the farm system

In Table 2 the physical production key performance indicators (KPI's) for the case farm and those for a Class 4 North Island Hill Country East Coast sheep and beef farm are shown so that the physical performance of the case farm can be compared to the industry average for the region. Drawing from Table 2, the case farm is almost twice the size of the average hill country farm in the region, but because of the equity partnership, it is owned by two farmers. The current physical performance of the case farm across most indicators is substantially higher than the average Class 4 North Island Hill Country East Coast sheep and beef farm. The stocking rate of the case farm is 32.5% higher than the regional average. The case farm has a greater ewe flock lambing rate of 145-150% in comparison to the Class 4 farm average at 128%. Similarly, the hogget lambing rate is much higher than the regional average because few farmers mate their ewe hoggets, preferring to mate as a two tooth. The amount of wool/sheep stock unit produced by the case farm (4.9 kg) is slightly lower than the Class 4 average farm producing 5.1 kg wool/sheep SU. However, taking stocking rate into account, the wool production per sheep hectare is 27% higher than the regional average. The beef cattle calving rate of the case farm (96%) is well above the average in comparison to the Class 4 average farm which is 84.2%. One of the best measures of productivity on a sheep and beef farm is net carcass weight production per stock unit and per hectare. The net carcass weight per hectare of the case farm is 40.6%

higher than the regional average (Table 2). Considering the higher stocking rate of the case farm, the net carcass weight per hectare of the case farm is 85.7% higher than the regional average, which demonstrates an impressive level of physical productivity being achieved on the case farm.

Table 2 Key production performance indicators of the case farm and the equivalent Class 4 North Island Hill Country East Coast sheep and beef farm.

Key production performance indicator (KPI)	**Unit**	**Case farm[3]**	**Class 4 N.I. Hill Country[4]**
Effective area	ha	1100	624
Total stock units (SU)	SU	12,812	5483
Sheep stock units	SU	6548	3231
Beef cattle stock units	SU	6264	2126
Stocking rate	SU/ha	11.0	8.3
Sheep: cattle SU ratio	%	51	60.3
Ewe flock lambing	%	145-150	128.1
Hogget lambing	%	80-90	-
Wool/Sheep SU	kg	4.9	5.1
Wool/Sheep hectare	kg/ha	53.9	42.3
Beef cattle calving	%	96.0	84.2
Net carcass weight production per SU	kg/SU	22.5	16.0
Net carcass weight production per effective hectare	kg/ha	247	133

Drawing from Table 3, the current financial performance of the case farm suggests it is well positioned in comparison to the average Class 4 farm for the region. The current gross farm revenue per effective hectare for the case farm ($1450/ha) is 46% higher than that of the average Class 4 farm ($993/ha). The farm operating expenditure (FOE) per effective hectare for the case farm is $1000/ha and $797/ha for the Class 4 farm. As such, based on these two financial indicators, the farm operating expense (FOE) ratio for the case farm is 68.9% which suggests it has more efficient expenditure in comparison to the average Class 4 farm which has a ratio of 80.3%. The EBITRm (earnings before interest, tax, rent and management wage) per effective hectare for the case farm is considerably greater at $450/ha in comparison to the average Class 4 farm ($364/ha). The data on the key physical production and financial indicators suggests that the hill

[3] Case farm 2021/2022 season performance
[4] Class 4. N.I. Hill Country Mean 2020-21

country sheep and beef farm system that the case farmer is operating is outperforming the average farm in the district.

Table 3 Key financial performance indicators of the case farm and the equivalent Class 4 North Island Hill Country East Coast sheep and beef farm.

Key financial performance indicator (KPI)	**Unit**	**Case farm[5]**	**Class 4 N.I. Hill Country[6]**
Gross farm revenue per effective hectare	$/ha	1450	992
Farm operating expenditure (FOE) per effective hectare	$/ha	1000	797
Farm operating expenditure (FOE) ratio	%	68.9	80.3
EBITRm (earnings before interest, tax, rent and management wage) per effective hectare	$/ha	450	364
Net carcass weight production per effective hectare	kg/ha	246	133

[5] Case farm 2021/2022 season performance
[6] Class 4. N.I. Hill Country Mean 2020-21

Chapter Five

5. Results and discussion

5.1. Introduction

This chapter sets out the key results and discussion about the case farmer's adaptation process in relation to climate change to answer the main research question for this study:

How does a farmer with high adaptive capacity identify change in the environment in relation to climate change and then adapt their farm system to cope with this?

The chapter also sets out to achieve the following objectives including to: 1) Describe the process an East Coast hill country sheep and beef farmer with high adaptive capacity uses to identify changes in the environment in relation to climate change, and 2) Describe the process an East Coast hill country sheep and beef farmer with high adaptive capacity uses to adapt their farming system to cope with this change. The chapter firstly provides an overview of the case farmer's adaptation process. Then each of the steps in the case farmer's adaptation process is described in more detail and compared to the literature.

5.2. An overview of the case farmer's adaptation process

The adaptation process used by the case farmer is illustrated in Figure 15. The case farmer's adaptation process can be usefully separated into three major stages: 1) sense-making, 2) SWOT analysis and strategy formulation, and 3) strategy implementation and control. During the sense-making phase, the case farmer firstly, 1) scans his operating environment for cues that indicate a change in the environment, then 2) using those cues, he identifies that there is, and or will be, a change in the operating environment, and then 3) he assesses the nature of the change and its impact on his farming system (Figure 15). Once the case farmer has made sense of the situation, he then undertakes a SWOT analysis and strategy formulation process. This involves: 1) assessing the opportunities and threats that flow from the expected changes in the operating environment, then 2) an internal analysis of the farm system via an assessment of the farm's current strategies to cope with the expected changes, and 3) the formulation of suitable strategies to take advantage of the expected opportunities and mitigate the expected threats (Figure 15). In stage two, if the case farmer identifies that his current strategies can cope with the expected threats and opportunities, no strategy formulation will occur, and he will return to stage one and continue scanning the environment (Figure 15). The final stage of the case farmer's adaptation process is the implementation and control of the new strategies developed in the previous stage. This stage of the adaptation process comprises of two steps: 1) implementing the strategy or suite of strategies to cope with the expected change in the environment and 2) monitoring and evaluating the implemented strategy to enhance learning and build capacity (Figure 15). In the final step of the process, the case farmer may refine a strategy, or he may decide a strategy is

inappropriate and remove it or replace it with another, hence the feedback link to the strategy formulation process (Figure 15).

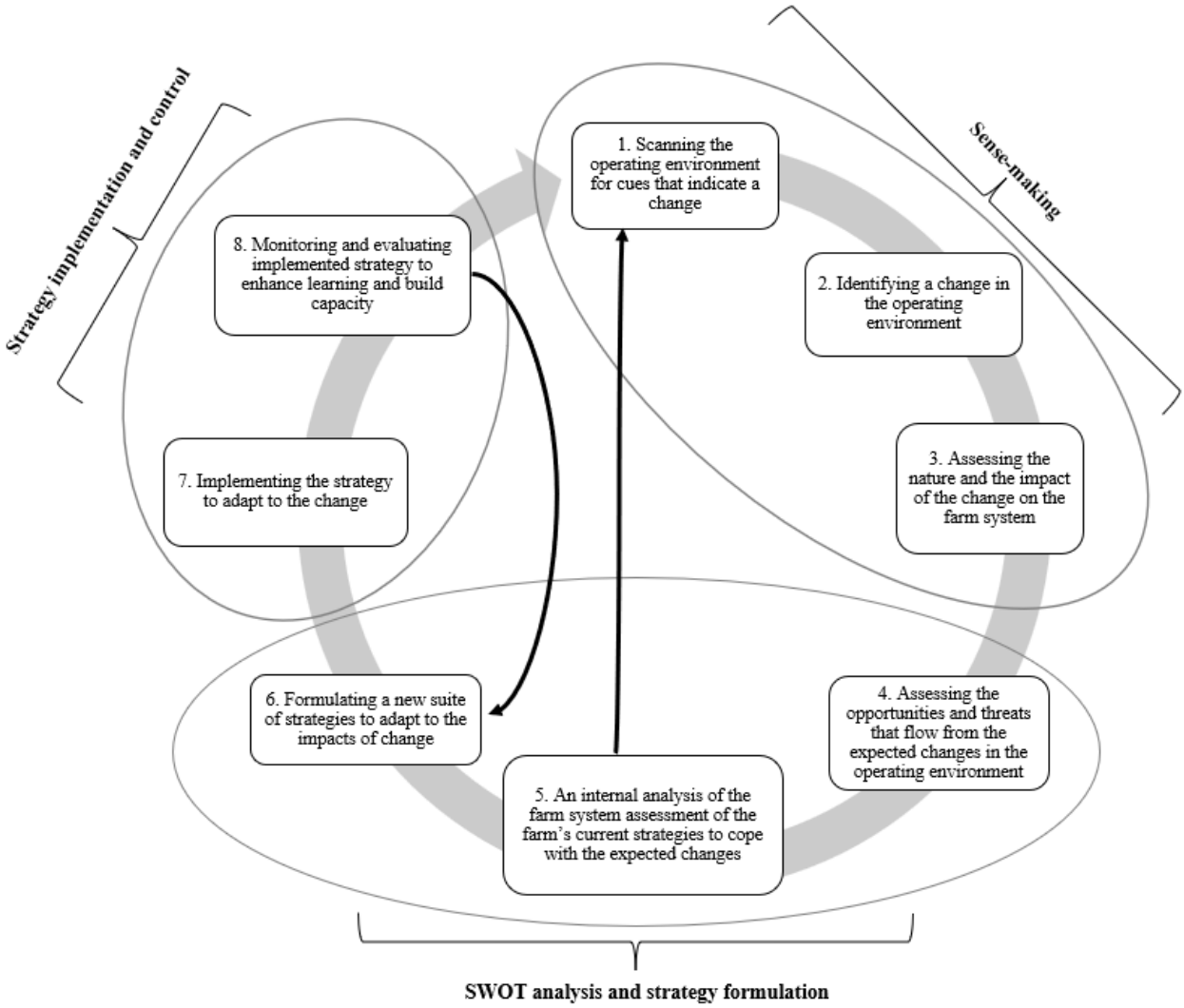

Figure 15 A model of the case farmer's adaptation process.

The case farmer's adaptation process is similar to the other adaptation processes (e.g., Risbey et al. 1999; Sutherland et al., 2012; Williams et al., 2009) reviewed in chapter two. The sense-making sub-process is similar to William et al.'s (2009) "Assess" phase, Risbey et al.'s (1999) signal detection and evaluation phase, and the trigger event phase in Sutherland et al.'s (2012) "Triggering Change" cycle. The SWOT analysis and strategy formulation sub-process is similar to the "Design" stage in William et al.'s (2009) model, the "Decision" component of Risbey et al.'s (1999) "decision and response" stage and the "active assessment" stage of Sutherland et al.'s (2012) "Triggering Change" cycle. The implementation and control stage of the case farmer's process is similar to "Monitor", "Evaluate" and "Adjust" steps in William et al.'s (2009) model, both the "Response" step in Risbey et al.'s (1999) "Decision and Response" stage and the "Feedback" stage in their model. Sutherland et al.'s (2012) "Triggering Change" cycle process has an

implementation and consolidation stage rather than an implementation and control stage as described in the case farmer's process. They used the term consolidation stage because through this process the farm system returns to path dependency. Sutherland et al.'s (2012) "Triggering Change" cycle process has a link from consolidation back to the active assessment step in the same way that the model of the case farmer's process has a link from monitoring and control back to strategy formulation. In contrast, William et al.'s (2009) model has an "Adjust" stage, where the new strategy is refined. One step in the case farmer's model that is not shown in the other models, is the link back to sense-making. This occurs if the farmer decides that his current strategies can cope with the changes identified in the environment and are likely to happen. Overall, the adaptation process developed from this study has extended the existing models by making some of the steps in the process more explicit and it has also made some of the feedback loops more explicit.

The case farmer's adaptation process is different to the strategic management process (Nell & Napier, 2005; Martin & Shadbolt, 2005) in that it starts with sense-making in relation to the external environment rather than with the formulation of a vision, strategic intent, and long-term goals for the farm business (Martin & Shadbolt, 2005). This in part is because the case farmer has already done this, and thus the focus of the farmer's adaptation process is in relation to climate change. The rest of the process is similar to the strategic management process where the process of evaluating the current situation is similar to steps four and five in the SWOT analysis and strategy formulation stage in the case farmer's process. There is not a distinctive gap analysis step in the case farmer's process, as is found in the strategic management process (Nell & Napier, 2005; Martin & Shadbolt, 2005). However, in step five of the case farmer's process (Figure 15), the internal analysis and capability assessment, the case farmer firstly assesses his farm system's capability to cope with the threats and opportunities he expects to occur because of climate change. In effect, he is assessing if these changes will prevent his farm system performing to the level he desires in the future, or if he needs to introduce additional strategies to ensure this. It is in effect, a form of gap analysis. The strategy formulation stage and the implementation and control stage are effectively the same as the final four steps in the strategic management process of: 4) generating alternative strategic options, 5) evaluating alternative strategic options, 6) choosing the preferred strategy (or strategies), 7) implementing the preferred strategy and 8) monitoring and evaluation. This suggests that it may be useful to make the strategy formulation process more explicit and include steps 4, 5 and 6 of the strategic management process within the adaptation process. The following section provides a detailed description of each of the stages and the steps within the case farmer's adaptation process and compares these findings to the literature. Section 5.3 to section 5.5., describes the sense-making stage, section 5.6., discusses the SWOT analysis and strategy formulation stage and section 5.7., discusses the strategy implementation and control stage.

5.3. The case farmer's sense-making process

The case farmer's sense-making process comprises of three steps: 1) Scanning for cues that indicate a change in the operating environment, 2) Identifying a change in the operating environment, and 3) Assessing the

nature and the impacts of the change on the farm system. Each of these steps will be discussed in the following sub-sections.

5.3.1. The scanning for cues that indicate a change in the operating environment

The first stage of the case farmer's adaptation process involves scanning for cues that indicate a change in the operating environment in relation to climate change. In both instances, the case farmer utilised a combination of individual and social sense-making to scan for cues that indicate a change in the operating environment. These findings are similar to the normative models of Riseby et al. (1999) and Williams et al. (2009) where the first step is to scan or monitor the operating environment in order to determine if it is changing. However, the authors do not use the term scanning, or link this to sense-making (Klein et al., 2006a,b). Sutherland et al.'s (2012) empirical model of the adaptation process, the second step in their model is identifying when a trigger event or opportunity occurs which will lead the farmer to consider if minor or major changes are required within the boundaries of the farm system. This might be due to an internal change in the business or a change in the operating environment, but again, the term scanning and sense-making are not used in the paper. Importantly, the case farmer scanned both tactical and strategic information to indicate if there is a change in their operating environment in relation to climate change. Tisch and Galbreath (2022) have looked at the role of sense-making by New Zealand dairy farmers and their use of tactical information in relation to drought events, but not in terms of climate change. In the following sections, the case farmer's tactical and strategic scanning processes are described and compared to the literature.

5.3.1.1. The scanning for tactical cues that indicate a change in the operating environment

The case farmer monitors a range of production factors in relation to his internal farm system. These factors include stock condition and performance (live weight gain), pasture growth and quality, pasture cover levels, feed availability (on-hand supplementary feed), pest and disease presence (weeds presence, facial eczema spores and internal parasites), and day-to-day weather on-farm (rainfall and temperature). The information obtained through his tactical monitoring methods (e.g., natural materiality observations) (Tisch & Galbreath, 2022) and his experience, or what Tisch and Galbreath (2022, p. 248) refer to as "his continuous immersion within the environment on his property" provides him with cues that indicate change in relation to the farm system and the climatic conditions at the time. These cues are used by the case farmer to make operational and tactical decisions to meet his tactical goals and targets. The case farmer also utilises his social networks (including neighbouring farmers and discussion group members) at the tactical level to interact with and share experiences of day-to-day weather and what the current conditions on-farm are.

Most of the production and weather data is monitored in the short-term (e.g., daily to monthly). However, at the tactical level, the case farmer also scans medium-term information (e.g., 6 -12 months). This is forecasted

information about the two main weather cycles that influence the East Coast known as El Niño and La Niña. He stated that: "*I do tend to follow, whether it's El Niño or La Niña. La Niña is typically right for us especially with the easterly rain we get. Traditionally they say the East Coast is supposed to be dry, but we have seemed to catch good rain from the La Niña cycles. I feel that La Niña has largely been our weather pattern since I've been here for the last 12 years and has traditionally been more favorable".* Risbey et al.'s (1999) model of agricultural adaptation to climate change suggested that farmers might use short-term, medium-term (about weather cycles like El Niño and La Niña) and long-term signals for decision-making purposes.

The case farmer's sense-making process is similar to that reported by Tisch and Galbreath (2022). They found that dairy farmers make sense of changing conditions associated with drought events via three forms of sense-making. These farmers were utilising: 1) sense-making based on experience and daily immersion on-farm, 2) sense-making based on ecological materiality and observations through monitoring a range of production factors, and 3) social sense-making based on interacting with trusted peers to allow the early detection of cues. These three forms of sense-making are important and illustrate how the case farmer makes sense of change at the tactical level. Of particular importance in relation to sense-making about climate change is the tactical information that the case farmer collects over time. This allows him to build up a database of historical rainfall data along with production data. The use of this data to indicate a change in the operating environment is discussed in Section 5.3.1.2. Although tactical information is important for sense-making, the focus of this study is on adaptive capacity which is associated with strategic thinking and foresight capacity. As such it is also important to understand the case farmer's strategic perspective of scanning for cues that indicate change, and this process is described in the following section.

5.3.1.2. The scanning for strategic cues that indicate a change in the operating environment

The case farmer scanned for strategic cues about future changes associated with climate change. This sense-making process was carried out via individual and social sense-making. From the individual sense-making perspective, the case farmer explores and utilises a range of information sources to inform him about climate change. These information sources include the internet, magazines, rural articles in the newspaper (e.g., Farmers Weekly), the television (e.g., national news), radio, Beef and Lamb New Zealand industry resources, and meteorological websites (e.g., Metservice). These resources mainly provide information about climate change at the regional and national level with some international level information. A key source that the case farmer used at the regional level was the reports by the National Institute of Water and Atmosphere (NIWA) on the impact of climate change on the East Coast. Such forecasts inform him about the predicted long-term future changes (e.g., 10 to 30 years) in the climate for East Coast of the North Island including the Gisborne, Hawkes Bay and Wairarapa regions. These reports suggested that the East Coast would experience

drier conditions, particularly over summer and more frequent droughts. The reports also suggested warmer winters and an increase of weeds, pests, and diseases (e.g., kikuyu, facial eczema).

The key information sources that the case farmer has used to seek information about climate change at the global spatial scale is via the internet. *"Obviously with phones and technology the information is just out there, so you know Google, I've searched Google about global climate change".* To some degree this reinforced his view that climate change was happening, however because of discrepancies between what the regional long-term forecasts were saying and what his on-farm climate trend data was showing, he was struggling to determine exactly what impact climate change would have on his farm.

Other cues the case farmer draws on for individual sense-making is historical knowledge about the farm system and district. This knowledge can be separated into formal documented records or historical data, and informal or subjective knowledge based on the case farmer's experience, which is stored in his memory. His historical rainfall records for the property were collected as part of his tactical monitoring. Such records provide the case farmer with trends in the rainfall data that can be analysed to indicate a change in the climate at the local level. He stated, "*I guess it's my personal weather records that indicate the climate is changing. Yeah, it's just my personal history of the property and history of the district".* In addition to these formal records, the case farmer can draw on his historical knowledge and experience of the property and district to indicate changes in the environment. The important information the case farmer scans and retains in memory is: 1) information about extreme weather events (e.g., droughts, intense rainfall events and floods), and 2) information about climatic conditions and pasture production over key periods of the year (e.g., summer, winter). Much of the information about these key periods of the year are obtained through the case farmer's tactical monitoring system and are typically used to make tactical and operational decisions regarding stocking policies and key dates in the farming calendar such as mating, lambing/calving, and weaning.

From a social sense-making perspective (Klein et al., 2006a; Klein et al., 2006b; Weick, 1995), the case farmer interacts and keeps informed about climate change via community and social interaction, which is the third form of sense-making described by Tisch and Galbreath (2022). The case farmer has a large and extended social network of individuals in the sheep and beef industry. The main individuals that the case farmer networks with on a regular basis include his family, equity partners, on-farm employees, neighbouring farmers, and the local farmers within the Beef and Lamb New Zealand discussion group. There are also several other individuals which he interacts with including his farm accountant, rural bank manager, stock agents, veterinarians, and fertiliser and pasture specialists, as well as local farm consultants and other rural professionals including regional council staff. He implied that *"There's plenty of resources out there and people that will help, but it's just about tapping into the right one, which I'm happy to do"*. He interacts with many of the local farmers within the discussion group to exchange knowledge and on-farm experience of changing climate conditions. *"I'm involved in a discussion group, and I've got neighbors around the*

district that I talked to, and I network with other farmers, but I have traditionally not used a consultant or farm adviser. I do consult with them, so that I can bounce ideas off them if I must, but traditionally I just use my own knowledge, and gut feeling". He is open to extending his social network, however at this stage he feels he has enough key individuals (including the previous owner, Beef and Lamb New Zealand staff, regional council staff, and local farm management consultants) and resources to access and inform him about changes associated with climate change. Such interactions and sharing of experiences provide the case farmer with general discussions about climate change and the opportunity to recognise cues that indicate change based on the perspectives of other farmers in his local district, and the changes that theyt are currently experiencing and the changes they anticipate occurring in the future. The engagement with other farmers can extend the perspective of the case farmer and support his sense-making efforts and thus enable him to recognise and identify change in his operating environment. This finding is supported by the empirical environment management literature where Tisch and Galbreath (2022) suggested farmers have a high sense of trust between one another and openly engage in discussions to share experiences and knowledge.

In terms of social sense-making, an important source of information is the previous manager of the farm he now operates. The case farmer draws on the previous manager's experience with the farm and compares it to his own experience since he has taken over the farm. This provides the case farmer with 50 years of weather records and production data and experience since the 1970s through to the present day. Such information is useful for looking at trends in relation to climate change (see section 5.4).

In summary, the material on how the case farmer scans for cues that indicate a change in the operating environment in relation to climate change highlights the complexity of the process. As suggested by the literature (Klein et al., 2006a; Klein et al., 2006b; Weick, 1995), he uses both individual and social sense-making and draws on a wide range of information sources and a broad social network. The case farmer undertakes individual sense-making (e.g., scans for cues that indicate change) on several different spatial scales (e.g., local regional and global) and temporal scales (e.g., short, medium, and long term), similar to that postulated in the normative farm management literature by Risbey et al. (1999). Risbey et al. (1999) postulated one of a few process models used by a farmer to adapt to climate variability and change. Risbey et al.'s (1999) suggested that farmers who are more operational (e.g., production) focused tend to define a cue (e.g., signal) that indicates change as "the processes in which they can observe at their characteristic scale of attention" (p.139). This study has highlighted that the case farmer draws on information from a range of spatial and temporal scales to help him make sense of climate change. However, the most relevant information is that which relates to his local scale, e.g., his district and farm and the historical trends he is observing in relation to theclimate. Similarly, as postulated by Risbey et al. (1999), the case farmer perceives long term climate change forecasts (e.g., the next 30-40 years) as irrelevant to his current on-farm decision making as it is too far into the future to be concerned about. These findings on scanning support the normative farm management theory postulated by Risbey et al. (1999) which suggests farmers ignore cues

(e.g., signals) depending on their interpretation and relevance of the information and, thus will search for cues on one temporal scale but may not necessarily search and monitor cues on another. Farmers in other studies outside of New Zealand have reported similar findings. For example, a study of Danish farmers (Woods et al., 2017) and smallholder farmers in South Africa (Gandure et al. 2013) reported that farmers believed that forecasts about the potential impacts of climate change were not useful to them, because they were too far into the future (≥40 years) to be relevant to their current decision making. The following section discusses the next step in the case farmer's sense-making process, how he identifies change in the operating environment using the information he is scanning.

5.4. Identifying a change in the operating environment

The first step in the case farmer's sense-making process is to scan the operating environment for cues that may indicate that the environment is changing. The case farmer then processes this information to see if it is indicating a change in the environment. These two sub-processes are closely linked and often occur almost concurrently. The case farmer uses a process of comparison and triangulation to identify change in the environment in relation to climate change. As such, he is looking to see that his different information sources are consistent in that they are all suggesting the climate is changing. The case farmer also trusts some information sources more than others. His most trusted sources are local in terms of his historical on-farm information and information from trusted local farmers and rural professionals. Another important source of information is the regional report on climate change impacts for the East Coast produced by the National Institute of Water and Atmosphere (NIWA) and meteorological websites (e.g., Metservice).

As stated previously, the case farmer is drawing on information he has scanned himself or through his networks and he is using information across different spatial and temporal scales as postulated by Riseby et al. (1999). In terms of spatial scales, he is using local (on-farm, district), regional, national, and global data to assess if the climate is changing. Importantly he is comparing his local information to information he has collected at other scales as a form of triangulation. At the global scale, he uses the news (e.g., TV, radio and newspaper, news apps (e.g., Stuff), radio (e.g., rural programmes), and actively searches on Google for cues that indicate the climate is changing. National information is obtained from the news, farming magazines, seminars and other resources from Beef and Lamb New Zealand and other rural organisations (e.g., banks, fertiliser companies etc.), and reports on the impact of climate change nationally produced by NIWA and meteorological websites (e.g., Metservice). Regional information is sourced from the news, radio, discussion group meetings, Beef and Lamb New Zealand field days and resources, regional council staff, rural professionals, and regional climate change reports produced by NIWA. Local information is sourced on-farm, from family, from local farmers, rural professionals, regional council staff, discussion group meetings and Beef and Lamb New Zealand field days. The case farmer compared this information both within a scale and across scales to assess if it is consistently indicating that climate change is occurring. Importantly, he had

noticed that at all spatial levels from local to global, the information was suggesting that the climate was changing.

The case farmer also scanned information across a range of temporal scales to identify if the climate was changing. He again compared across the sources to assess if they were providing a consistent message about a change in the climate. His local historical on-farm data and information from other farmers and rural professionals in the district suggested the climate had changed over the last 12 years. The case farmer drew on regional climate change forecasts about how the climate might change over the next 10 to 30 years. It looked at the changes that were expected over the 10-year time intervals through until 2050. The farmer also scanned other reports at the national level and from a global perspective. The climate change forecasts all indicated that the impacts of climate change would be exacerbated over time as global temperatures increased. As such, from a temporal perspective, the information was consistent in that the climate was changing and the forecasts also consistently stated these changes would be exacerbated over time.

The process the case farmer uses to identify if the climate is changing is similar to that advocated in the sense-making literature (e.g., Klein et al., 2006a; Klein et al., 2006b; Weick, 1995) where the focus is on extracting cues from the environment to help the individual develop meaning and seek new information to make sense of a change in the environment. The case farmer is using both individual and social sense-making to make sense of the situation as proposed by Klein et al. (2006a,b). This study highlights, that the range of information in terms of both sources and scales (spatial and temporal) that the case farmer uses to make sense of what is happening with the climate is important. Few studies have highlighted this point, but Tisch and Galbreath (2022) did report that New Zealand dairy farmers used a wide range of information to make sense of climatic information for tactical decision making in relation to an impending drought. These findings also support the normative model proposed by Risbey et al. (1999) who suggested that a farmer would scan the environment at different spatial and temporal scales to identify signals that indicated the environment was changing. Risbey et al. (1999) did not specify how this information would be used to identify that the environment was changing. This study shows that the case farmer is drawing on multiple sources of information at different spatial and temporal scales and comparing them to see if it is consistently informing him that the climate is changing. So, this is a form of triangulation. This is telling him climate change is occurring. This step is important, because if he perceived that it was not changing, he would not move onto the next step in the adaptation process, it would be business as usual and as Sutherland et al. (2012) pointed out, the farm system will continue towards a stable trajectory. As Sutherland et al. (2012) stated, the identification of change initiates a farmer to process information about such change and begin the adaptation process. In the normative strategic management literature, Ginter et al. (1985), French (2009), Martin and Shadbolt (2005), Nell and Napier (2005) and Shadbolt (2007) have described identifying change in the external environment through a situational analysis, but unlike this study, they provide little insight

about how a farmer does this. The following section describes the final sub-process of assessing the nature and the impacts of such change on the farm system.

5.5. Assessing the nature and the impacts of the change on the farm system

The next stage of the case farmer's adaptation process is a continuation of the sense-making process where he develops an understanding of the nature of the change and its impacts on his farm system before acting upon it through the decision-making process. This process was postulated in Risbey et al.'s model of a farmer's adaptation process for coping with climate change. It is also in line with Klein et al.'s (2006a,b) sense-making process from the organisational literature. An interesting finding from this study is that the case farmer uses a wide range of information sources at different spatial and temporal scales to assess if the climate is changing in general, but once he has identified that it is changing, he then shifts his focus to the local scale to assess the nature of the change for his local climate and what impact this will have on his farm system. As Klein et al.'s (2006a,b) work on sense-making identified, the recognition of a cue is likely to 'trigger' the individual to develop further meaning of what may be going to happen or what is happening in their environment. Based on this, it means that once the case farmer accepts that the climate is changing in a general sense, he then undertakes further steps to understand what that means for his local context.

Once the case farmer has identified that the operating environment is changing, he will periodically assess the nature of the change in relation to his farm system and then based on that, what impacts this might have on the farm. This assessment process is triggered by the changes in the environment that are observable to the case farmer within his characteristic scales of attention. From his scanning process, the case farmer has a wide range of information that varies in terms of source, trustworthiness, temporal (historical, current, and future or forecasted climate information) and spatial scale (local, regional, national, and global). Such information is analysed to estimate what impact climate change will have on the local climate that may impact his farm over the next 3 - 5 years. To assess this, the case farmer draws on his historical climate and production data and experience to consider what the trend is for the climate on-farm. He also triangulates this with information from other local farmers, rural professionals, and regional climate reports from NIWA and the meteorological service. Sutherland et al. (2012) and White et al. (2009) stated that there are various factors that determine how a farmer perceives change. They include personal experience, social memory via shared experiences and objective information, historical and past events knowledge, and their level of social networks. These factors were important for the case farmer and this study highlighted the tension between local knowledge and scientific knowledge from climate change forecasts and how a farmer must decide when different sources provide conflicting information. This is an important issue in relation to adaptation, as how do farmers make sense of the information they are receiving from different sources and at different scales (spatial and temporal).

The case farmer's most important sources of information for assessing the nature of the change in the climate and the local farm level over the next 3 - 5 years are his own historical climate and production records and experience, and the same information that is held by the previous manager of the farm. He makes the comment: *"Locally I've talked to the previous manager that was here for 38 years and I've now been here 12 years, so there's 50 years of weather records roughly and the climate's changed significantly since he was here"*. He continues along these lines: *"Like I say, I've talked to the previous manager of this property, and he said it was usually burnt off in October and brown, and he found strategies to farm with it here especially through the 70's and 80's, I think, he said. But since I have been living here for the past 12 years, it has not quite been a summer safe property, but you would almost say summer safe as rainfall seems to have increased in the summer".* The case farmer used this on-farm climate data along with his production data and experience to identify that winters were becoming warmer, and summers were becoming wetter. He also stated that *"Our rainfall has increased and whether that will continue or whether it's an anomaly we don't know. Our winters seemed to have got milder, with warmer temperatures and we haven't had cold southerlies or miserable wet winters for a while now".*

The case farmer has then compared this information to the regional climate change forecasts for the East Coast. The regional forecasts for the East Coast predicted that the climate is going to become hotter and drier for longer, with increased severity and frequency of drought and extreme weather events such as ex-tropical cyclones, and an increase in baseline winter temperatures of which he thought was an unfavourable view of the future. He has identified that although the climate is changing on his farm, not all the changes are in line with the regional forecast's predictions, particularly in relation to summer rainfall. The current climate conditions that he is experiencing on-farm are far more favourable for sheep and beef production and present a more positive outlook than what has been predicted for the East Coast. He stated, "*Like I say, other than what I've been told, that our climate is going to become hotter and drier, and for longer and we're going to get increased extreme weather events, is what the climate experts tell us for the East Coast and the North Island. But here on-farm it's been the complete opposite. We have had better rainfall spread and currently what they have predicted is not what's happening locally".* This highlights a problem for farmers, is that regional climate forecasts may not reflect the changes farmers are observing locally on-farm possibly due to micro-climate effects and the limitations of the climate models due to scale.

To determine the likely nature of the impact of climate change on his future local climate over the next 3 – 5 years, the case farmer uses an extrapolation method. His extrapolation method draws on the current climate trends he is observing in his operating environment (e.g., local climate and within his farm system), his perception of the changing climate as well as his experience and knowledge of his farm system to determine the nature of change, and thus estimate the impacts of these conditions through a process of deduction. His sense-making process suggested that he could expect warmer winters, wetter summers, warmer temperatures in general, and an increase in intense rainfall events out of season. He anticipates that these conditions are

likely to continue into the near future (e.g., over the next 3 - 5 years). However, he anticipates the risk of drought to remain, given the warmer temperatures, and because traditionally on the East Coast of the North Island his farm system has typically experienced a summer dryland environment.

The study highlights that information at the local level was the most important in influencing how the case farmer perceived change in relation to the climate impacting his farm due to climate change. Sutherland et al. (2012) and White et al. (2009) reported that a range of factors including personal experience, social memory via shared experiences and objective information, historical knowledge of past events, and knowledge from their social networks determine how a farmer perceives change. This was also the case for this study. Gandure et al. (2013) also reported that South African farmers acknowledged the long-term changes in climate, however their view of "climate change" was based on the short-term effects that were occurring currently. In relation to the use of climate forecasts, Gandure et al. (2013) reported that farmers have tended to ignore them because the time frames are too long-term to be relevant. However, in this case, the case farmer accepted some aspects of the regional climate forecasts such as the expected increase in temperature, and an increase in intense rainfall events because his on-farm data and personal experience, and historical knowledge suggested these changes were occurring. However, he ignored other elements of the regional climate forecast such as the prediction that summers would become drier because his local on-farm data and experience did not support this.

These findings also support the view that a farmer's perceptions of their operating environment are largely knowledge-based (Öhlmér et al., 1998; Shadbolt & Bywater, 2005). Whereby the case farmer has compared his local knowledge of changes in climate with regional forecasts and found that the forecasts appear to be inaccurate for his location, except for a few elements. As such, he is not using the information from these regional forecasts as the basis of making decisions about climate change adaptation. Interestingly, although his on-farm data suggested summer rainfall was increasing, he still considered that the risk of drought was important based on his historical experience with drought on his farm and the tendency for drought to occur on the East Coast in general. As such, he did not rely solely on historical trend data on summer rainfall. This was tempered by his historical knowledge that drought was an historical problem on the East Coast. Similar findings have been reported by Gray et al. (2011) whereby New Zealand, Hawkes Bay hill country sheep and beef farmers have several risk management strategies in place to manage and cope with dryland environments which are subject to drought and the upside risk (better than expected conditions).

Once the farmer had decided on the likely changes in the local climate over the next 3 - 5 years due to climate change, he then assessed what impacts these would have on his farm system. This is similar to that postulated in Risbey et al.'s (1999) adaptation process. Using a process of deduction and drawing on his detailed knowledge of the farm system, the case farmer estimated that these changes in the climate would have the following impacts on his farm system. First, he deduced that warmer winters would increase pasture growth over the winter months. He then deduced that wetter summers will likely increase the pasture growth

and improve pasture quality over the summer due to the increase water availability. This will reduce the risk associated with droughts and thus reduce the likelihood of the severe feed deficits he had previously experienced on the property. However, he also deduced other impacts to his farm system from these changes such as a greater risk that pasture supply would exceed stock feed demand and consequently, pasture quality would deteriorate. The case farmer also deduced that warmer temperatures may also increase the incidence of weeds, pests and diseases which may negatively affect pasture quality and animal production. Specifically, he thought that the incidence of weeds such as kikuyu, nodding thistles, and blackberry, as well as pests and diseases such as facial eczema and internal parasites would increase given the warmer temperatures. Gandure et al. (2013) also reported that South African farmers were concerned about the impacts of weeds, insects, and internal parasites on production.

The case farmer also believed that changes in the climate would result in more intense rainfall events out of season caused by extreme weather events (e.g., ex-tropical cyclones) and that these were a definite threat to his farm business. Such events are estimated to increase the likelihood of soil erosion and slips on the steeper hill country and increased flooding on low-lying flat country. Such events are likely to decrease pasture production and utilisation on the areas that have been damaged. There is also likely to be increased damage to on-farm infrastructure (e.g., fences and farm tracks) and key transport infrastructure (e.g., roads and bridges) due to slips and flooding. This would prevent effective control of stock on-farm and limit the case farmer's ability to transport stock off-farm for sale when required, both of which would negatively impact on-farm profitability. He stated that this was experienced during and post-cyclone Gabrielle in February 2023. Danish farmers in a study by Woods et al. (2017) were relatively unconcerned about a variety of specific climate change impacts but were most concerned about severe storms causing damage to structures and trees on-farm. However, other studies of farmers have not mentioned any concerns about the impact of climate change on infra-structure that would prevent them accessing markets.

In summary, the case farmer used an extrapolation process based on trend analysis of climate change at the local level to determine the nature of the change in climate for his farm system over the next 3 - 5 years. Once the nature of these changes was estimated, he drew on his experience and knowledge, then deduced what impact such changes in climate would have on his farm system over the next 3 - 5 years. Although several authors (e.g., Adgar, 2006; Gallopin, 2006; Smit & Wandel, 2006; Turner et al., 2003) have stated that an important aspect of the current stage is that the farmer focuses on determining probable impacts of change to their farm system, little has been written about either of these processes in the farm management literature. The following section describes the next stage of the adaptation process where the case farmer undertakes a SWOT analysis and the strategy formulation process.

5.6. The case farmer's SWOT analysis and strategy formulation process

The case farmer's SWOT analysis and strategy formulation process comprises of three steps: 1) Assessing the opportunities and threats that flow from the identified impacts of the change, 2) Undertaking an internal

analysis of the farm system and assessing its capability of mitigating the identified threats, and taking advantage of the opportunities that are expected to result from the change in the operating environment, and 3) Formulating a suite of strategies to adapt to the threats and opportunities from climate change. Each of these steps will be discussed in the following sub-sections.

5.6.1. Assessing the opportunities and threats that flow from the identified impacts of the change

Once the impacts on his farm system had been deduced, the case farmer then undertook an assessment to determine if these impacts were likely to be a threat or an opportunity for the farm business. This is similar to the external analysis component of a SWOT analysis as proposed by Martin and Shadbolt (2005), and Nell and Napier (2005). To assess these, the case farmer drew on his detailed understanding of his farm system and how changes in climate would impact on his farming system and its performance and profitability, and then he classified these impacts as either a threat or an opportunity. In some cases, a particular impact was classified as both a threat and an opportunity, something not mentioned in the strategic management literature. This classification process was important, because on the basis of this, the farmer had to develop strategies that either mitigated the impacts if they were considered threats, or took advantage of the impacts, if they were considered opportunities, or both.

The case farmer identified that warmer winters would increase pasture growth over the winter months. He identified that this would create an opportunity for the farm system because it would provide more feed over winter that he could take advantage of. Although the case farmer did not identify any threats that would arise from warmer winter temperatures, he identified that the general increase in temperatures was an important threat because it would increase the incidence of weeds, pests, and diseases. These may negatively affect pasture quality and animal performance. The case farmer also identified that wetter summers would provide an opportunity due to the likely increase in pasture growth rates and the improved pasture quality over summer. The case farmer identified the impact from this change in climate as an opportunity because he could take advantage of the additional feed and the increase in pasture quality. However, he also identified this specific change in climate as a potential threat. This was because if he did not control the extra pasture growth, pasture quality could deteriorate, and this would impact negatively on stock performance. Another threat he identified was the expected increase in more intense out-of-season rainfall events caused by extreme weather events such as ex-tropical cyclones. These would cause soil erosion and slips, flooding, and damage to farm (fencing, tracks, power) and local district infra-structure. The case farmer did not identify any opportunities from this specific change in climate except that if it happened in summer or early autumn it could provide additional summer and/or autumn feed and this could provide his farm system with an opportunity. The final threat that the case farmer identified was regarding drought, as the property has a historical experience with drought from October to April, whereby such conditions are traditional for the East Coast.

This study provides some insights into how a farmer identifies threats and opportunities from changes in the external environment. Little empirical work has been published on this process and the normative literature (Ginter et al.,1985; French, 2009; Nell & Napier, 2005; Shadbolt, 2007) provides limited guidance on how to do this. Martin and Shadbolt (2005) describes various approaches (e.g., PEST analysis) at a high level, but provided little detail on how to do this. They concluded by stating that "there is no hard-and-fast rules on how to do this (external) analysis, but it is important that it is done" (p. 101). The following stage of the adaptation process used by the case farmer is described in the following section which involves a SWOT analysis of the farm system and a capability assessment.

5.6.2. Undertaking an internal analysis of the farm system and assessing its capability of mitigating the identified threats and taking advantage of the opportunities that are expected to result from the change in the operating environment

Once the case farmer has identified the threats and opportunities that could arise due to the change in the operating environment, he then undertakes a thorough informal internal analysis of his farm business. This involves reviewing the strengths and weaknesses of the farm system. This is in line with the normative SWOT analysis process described by Martin and Shadbolt (2005), and Nell and Napier (2005) in terms of identifying the strengths (S) and weaknesses (W) that are relevant to the threats and opportunities he has identified from the external environment in relation to climate change. Once this process is undertaken, the case farmer then assesses whether his existing suite of strategies and associated tactics are suitable to mitigate these threats and take advantage of the opportunities. This is an important step because changes in strategy are normally costly in terms of capital, and/or the time required to plan and implement the strategy and develop the human capability to implement the strategy effectively (Sutherland et al., 2012). This is line with Cowan et al.'s (2012) work who suggested that an assessment of a farm system's tactical and strategic flexibility can determine how vulnerable the system it is to weather variability and a changing climate.

Similarly, Smit and Wandel (2006), and Adgar (2006) thought that it is useful to understand how vulnerable and exposed the farm system may be to climate change. However, the normative literature on SWOT analysis (Martin & Shadbolt, 2005; Nell & Napier, 2005; Shadbolt, 2007) tends to ignore this step and focuses on the formulation of new strategies to meet the threats and opportunities in the operating environment. Through his internal analysis process, the case farmer has highlighted several key strengths within his farm business. Analysis of these strengths identified to the case farmer that his farm system had the strategic and tactical flexibility (Cowan et al., 2012) to cope with the anticipated impacts (threats and opportunities) from climate change. As such, at the time of the interview, he did not believe that he needed to formulate additional strategies to cope with these threats and opportunities. Little has been written about this process in either the normative or empirical literature. Further details on the case farmer's internal analysis process and how he assessed the strategic and tactical flexibility of his farm system are described in the following paragraphs.

Overall, the case farmer believed that the timing of mating, lambing, and calving dates, and weaning in the various stock classes are adequately tailored to the micro-climate within his farm system. As such the consistency in performance provides a good indication that such farming policies operate optimally. The case farmer has identified the strengths and weaknesses of his system through a combination of benchmarking against other farms in his discussion group and comparing his management practices to best practice. This is similar to the process advocated in the normative farm management literature (Martin & Shadbolt, 2005). Although there is little published on how farmers identify the strengths of their farm business, the process used by the farmer is similar to that used by an expert farm management consultant in a recent paper by Gray et al. (2017). The farmer's analysis of his strengths highlighted that the state of his key resources (e.g., soil fertility, pasture species, level of subdivision, water supply, sheep, and cattle genetics), and the long term physical and financial performance of the farm was of a high standard. He also compared his management practices to best management practices (e.g., matching different stock classes to the appropriate land classes and coinciding lambing and weaning dates to match feed supply and demand). He is aware that his physical resources are of a high quality, and this enhances the farm's ability to cope with climatic variation and thus the perceived impacts of climate change. He stressed the importance of good levels of soil fertility, good pasture species, and good livestock genetics in ensuring the farm system is resilient. After a recent cyclone, the case farmer identified that although the farm is reasonably resilient, he had not considered problems with the district infrastructure, and how the loss of roading meant transporting stock to the sale yards and the meat processing facilities may be an issue. He is also aware that he needs to be considering how his farm system is best suited to the changes and impacts in relation to climate change as it develops. These points come through in the following quotes:

- *"I think the farm system is well tailored in terms of having the right classes of stock on the right class of the land and the timing of lambing and weaning suits our climate pretty well and the infrastructure of the property. There is built-in flexibility in our system. I think it's proved to be repeatable, in terms of production, it has been climbing, so I think it proves that the system's pretty good".*
- *"I just think it's the basic resources, well the physical resources like good grass, subdivision, water, and soil fertility. Good soil fertility is needed so you grow grass when you cannot grow grass. If you can grow grass and you have good soil fertility on the shoulders of drought or winter, you tend to grow a bit more and you grow grass for longer".*
- *"I'd like to think we're always breeding hardier, more efficient hill country sheep and beef cattle genetics-wise. I guess there's value of having good genetics as well. Which I've been happy to spend quite reasonable amounts of money on. I think it's a cheap investment which helps pay dividends".*
- *"I think we run a pretty robust system, but I guess with Cyclone Gabrielle, it has given us all a bit of a wakeup call with just how robust that system is when you cannot physically get stock off farm".*

- *"I always need to be thinking about climate change and just how it is changing and how my system is then suited to those impacts and changes".*

The case farmer also used benchmarking to identify his farm system's weaknesses. He benchmarks his farm system's physical and financial performance and his management practices against farmers in his local Beef and Lamb New Zealand discussion group. This approach is similar to the process advocated by Martin and Shadbolt (2005) and used by an expert farm management consultant (Gray et al., 2017) to identify the weaknesses of a farm business. This enables the case farmer to understand how he is performing in comparison to other farmers within the district. The case farmer makes the comment *"I probably need to be challenged about why I'm doing this and why I'm doing that, and I guess it's partly an age and the stage that I'm at in life, I like to think that what we do is right for the system. I'm involved with a discussion group and the farmers involved can be honest with me and hopefully that's a bit of a rain check. I guess we benchmark in the group also in terms of the physical production and financials, so I've got a pretty good indication of how I'm performing".* The case farmer identified that one of his weaknesses in the following quote: *"It would be naive to say it didn't have any weaknesses. I guess it's probably more based around the fact that I'm in a comfort zone. I guess I tend to not get other people involved such as a farm consultant or advisor in the management of the farm. I guess if I did, they would likely challenge what I'm doing and then that gets uncomfortable".*

In regard to how the case farmer assesses the vulnerability and capability of the farm system, he does this via reviewing his on-farm resources and current suite of strategies to see if they can cope with the threats and take advantage of the opportunities. Drawing from the main threats and opportunities that were identified in Section 5.4.1., the case farmer currently has a mix of strategies to cope with climatic variation. The case farmer has in place a set of strategies designed to enhance his general resilience. These include reducing debt levels, maintaining a high level of physical and financial performance, and improving the state of the farm resources (land, labour, and capital) to ensure the farm can buffer the various sources of uncertainty. The case farmer also has a range of strategies and associated tactics to cope with current known uncertainties in relation to market risk and climate change. These uncertainties include variation in pasture production, extreme weather events such as droughts and floods, and variation in product and input prices. The main strategy that is in place to manage variation in pasture production is operating a production system that can quickly adjust feed demand by altering the farm carrying capacity. The typical stocking rate for the farm system is 11 SU/ha. However, to manage variation is pasture production, the stocking rate can be reduced to 6-8 SU/ha if there is a feed deficit due to drought or potential flooding. He does this by removing non-capital sale stock (e.g., store or prime lambs, or beef cattle male progeny at 24-30 months of age) off farm to sale yards or the meat processing facilities. He also sells R2yr bulls to the dairy industry. In contrast, if surplus feed is available over summer and autumn, the farm can retain sale stock for longer and grow them out to heavier weights. Additional stock can be purchased if there is surplus feed over summer or autumn such as store lambs or R2yr bulls. Additional stock can be used to increase pasture utilisation and maintain pasture

quality during a pasture surplus. Limited supplementary feed is made on farm (e.g., baleage), however during periods of surplus pasture, the flat and rolling country can be shut up and cut for baleage. The baleage is then stored and used in a feed deficit.

As a drought risk management strategy, the case farmer has an early lambing terminal ewe flock (1000 ewes). The terminal ewes start lambing from mid-July, whereas the mixed age (MA) ewes and two tooths planned start of lambing is mid to late August. The terminal ewe flock strategy allows the case farmer to sell a large proportion of lambs in late November to early December, prior to the critical summer period when drought risk is high. Historically, the most critical period for the farm system is October to April where drought risk is high due to rainfall variability and its influence on pasture growth and supply. The early weaning of the lambs from the terminal ewe flock allows the bulk of the case farmer's cull ewes to be sold to the works early. The de-stocking strategy is useful particularly when pasture deficit occurs. He stated that "*The previous manager and the farm consultant at the time helped to develop those policies and that's why they were put in place, to deal with worse weather than what I've experienced. I question why I'm doing some of the early lambing, because it usually results in a 10-20% lambing percentage loss. But I can almost guarantee the day I stop doing that early lambing, we will have a drought. I figure I'll keep that policy, but I'll just tweak it to make it better so I'm not dropping 10 or 20%. Currently it's almost on par of doing the job better, and I've learned a little bit, and we are not dropping any production or very little production".* However, to cope with, or take advantage of surplus summer feed, the case farmer can delay weaning and hold lambs for longer on-farm. The early lambing ewe flock could also be used to utilise the increased winter pasture growth. The case farmer makes the decision to mate his hoggets depending on pasture supply on-farm, but also to take advantage of additional winter and summer pasture growth. The ewe hoggets are mated in May and lambed in early October, with lambs finished over the summer. The case farmer maintains a feed reserve which includes 120t of maize silage. The maize silage is utilised throughout the year when pasture deficits occurs or as a supplement during extreme weather events when stock may be under stress.

He also has planted radiata pine on steeper and marginal hill country and has in place an annual poplar pole planting programme to stabilize erosion-prone land which are expected to cope with ongoing extreme weather events. He also selects high FE tolerant rams which have high DPX (Dual Purpose) and NZMW+X (NZ Maternal Worth index) indexes specific to FE to strengthen the FE tolerance of the ewe flock. The case farmer also has in place a weed management programme, particularly for managing nodding thistles and blackberry as these have become problems in the past. The case farmer has previously sprayed 75ha of nodding thistle and consistently manages areas of blackberry through spraying. He stated, *"I go out on-farm and check the main areas where the nodding thistles have been particularly bad, and I also take pictures every year for farm records so that I am able to keep on top of the areas that are the worst"*. He also manages kikuyu through his grazing management to maintain good pasture quality across the property. The case farmer keeps up to date with internal parasite management through attending field-days as well as alternating active ingredients in internal parasite drench to reduce drench resistance in his sheep enterprise.

The internal analysis process used by the case farmer is a similar process to that described by Martin and Shadbolt (2005) in the normative strategic management literature. They stated that the external assessment of the environment provides a backdrop against which the internal analysis is undertaken. The case farmer identified the important opportunities and threats he might face with respect to climate change and then undertook an internal analysis of his farm system to assess if it could cope with these. As with the case farmer, the internal assessment process set out by Martin and Shadbolt (2005) included an assessment of the farm resources, the physical and financial performance of the farm and the farm's management practices. Based on the internal analysis and capability assessment, the case farmer determined that his current suite of strategies is capable of coping with the estimated impacts of change in relation to climate change. As such, the case farmer did not formulate a new suite of strategies to cope with the expected impacts of climate change over the next 3 – 5 years, and instead he then returns to scanning the environment. This is an important finding because a change in strategy is normally costly in time and capital and as such, it is important to identify if the current suite of strategies can cope with the expected impacts from climate change. Because the case farmer had not formulated a new suite of strategies in relation to climate change in recent years, the following section describes the strategy formulation process he has used in the past to cope with expected changes in his operating environment in relation to climate change.

5.6.3. Formulating a suite of strategies to adapt to the threats and opportunities from climate change

The case farmer had explained his adaptation process based on his latest assessment of the impacts that climate change was expected to have on his farm system. However, he had decided that his current suite of strategies could cope with these expected changes over the next 3 – 5 years and as such, he did not need to formulate a new suite of strategies. To gain insights into the rest of the case farmer's adaptation process, he was asked about previous instances where he had formulated new strategies to cope with the expected impacts of climate change and this is the focus of this section and the subsequent sections on the other steps within the case farmer's adaptation process.

In the past, the case farmer has used the same process as in the previous section to assess if his current strategies could cope with the threats and opportunities from climate change that he has identified. Earlier in his time on the farm, it suffered from dry summers and drought. As such, the on-farm historical climate data was in-line with the climate change forecasts that the East Coast would be warmer and summer rainfall would be less and droughts more frequent. These strategies include the adoption of a terminal ewe flock to reduce feed demand over summer, the planting of 100 ha of rolling country into drought tolerant pasture species (e.g., cocksfoot, subterranean, and red clover), not mating ewe hoggets, flexible stock policies that allow rapid destocking, feed reserves (120 tonnes maize silage), the introduction of FE tolerant rams and the development of a new reticulated water supply system. He has also planted 120 ha of forestry for carbon farming on his steepest, least productive country as another response to climate change. To provide some

insights into the case farmer's strategy formulation process, he was asked about how he formulated his strategy for the new water reticulation system.

The new water reticulation system

The case farmer's formulation of a strategy to invest in a new water reticulation system was undertaken as the climate change forecasts for the East Coast were suggesting that conditions would likely become warmer, with drier summers and an increase in the frequency of droughts. When the case farmer was considering this change, the farm had had a history of dry summers and droughts, he considered that these expected changes in climate would pose a threat for his farm system, particularly his stock. The case farmer did an analysis of his internal assessment of his farm system, and this identified that given this potential threat, his stock water supply was an important weakness. He identified that the pumps used to reticulate some of his stock drinking water were unreliable in a drought. The water tanks were also incorrectly positioned on-farm to provide water to a large proportion of the farm area. As such, stock had to rely on water from either creeks, streams and man-made water catchment dams or ponds, however during a drought these would often dry up. Due to the lack of water, these areas of pasture were severely underutilised during drought conditions. He stated that *"there's no point having all the grass in the world on one part of the farm, and then you've got no water in those paddocks, and you can't utilize the grass".* Stock dams required ongoing maintenance because they had to be cleaned out regularly with a digger which was expensive. The dams were also identified as a major hazard for stock when water levels were low, and they became stuck in the mud. The lack of good clean water sources also created animal health problems and affected stock performance.

Based on the expected threat from climate change of drier summers and more frequent droughts, and the identification of the current stock water system as an important weakness in relation to stock performance under such conditions. The case farmer identified that he needed to invest in an improved water reticulation system to future proof the farm against the expected impacts of climate change. This would improve stock access to water and improve the quality of the water particularly during late spring, summer and early autumn which would be important if summers were to become drier and droughts more frequent. Such a system would provide the stock with access to clean drinking water which would improve animal health and stock performance, and greater pasture utilization. The case farmer's process to formulate a new strategy to cope with the impacts of climate change is similar to the process in the strategic management literature (Martin & Shadbolt, 2005; Nell & Napier, 2005) where he undertook an analysis of the external environment to identify a potential threat and then undertook an internal analysis of the farm resources to identify an important on-farm weakness in relation to that threat. He then undertook a creative process, the strategic thinking aspect of strategic management (Duranovich, 2015; Martin & Shadbolt, 2005; Nell & Napier, 2005), to come up with a strategic option to mitigate the impact of the threat and minimise the on-farm weakness.

Once the new strategy was identified, the case farmer sought out information and advice from his social networks and other information sources. This is similar to the "Active Assessment" stage in Sutherland et al.'s (2012) "Triggering Change" cycle, the "Design" stage in Williams et al.'s (2009) adaptive management process, and the "Decision and Response" stage in Risbey et al.'s (1999) decision making framework for adaptation in response to climate change. In this stage, the case farmer undertook a more formal and rational strategic planning process (Duranovich, 2015). First, the case farmer accessed an on-farm study carried out by a local consultancy firm on the value that reticulated water may provide for hill country farming systems, in terms of improved animal health and performance, and return on investment. The findings from this study suggested that stock performance would be enhanced through the provision of clean drinking water. The case farmer talked to a local agricultural engineering firm about options and decided that a water reticulation system would best meet the farm's needs. He held discussions with all directors of the farm business about investing in a new water reticulation scheme across the entire farm. Following the discussions with all directors, the costing of the new system was then developed with the local engineering firm that would install the system. The case farmer then undertook an analysis of the strategy using a financial budget analysis with help from his rural bank manager comparing the scenarios of with, and without, a new water reticulation scheme. In the analysis, assumptions were made about the impact of the new water reticulation scheme on stock performance. Based on this analysis and after discussions with the bank manager and his equity partner, the decision to invest in a water reticulation system was made by the case farmer and his equity partner. This process is similar to the strategic management process, where it is recommended that farmers generate alternative strategic options, evaluate the different strategic options and then choose the preferred strategy (Martin & Shadbolt, 2005). In this case, the only plausible strategic option was to invest in a new reticulated water system, and as such no other alternative options were formulated. The other option is to do nothing or maintain the status quo.

The investment strategy (e.g., new reticulated water system) was formulated via the creative strategic thinking process (Duranovich, 2015; Martin & Shadbolt, 2005; Nell & Napier, 2005). The creative process was postulated by Martin and Shadbolt (2005) as an important function within the strategic management process, whereby the continuous crafting of strategy is necessary to find the best strategic fit for the farm system via an ongoing situation analysis (Martin & Shadbolt, 2005; Nell & Napier, 2005). The investment strategy (e.g., new reticulated water system) is based around building in flexibility to increase grazing capability across the farm system and to reduce the system's vulnerability to the impacts of increased incidence of dry summers and drought as highlighted in the situational analysis. The investment strategy can be categorised as a deliberate strategy according to Mintzberg (1987) (Figure 16). Mintzberg (1987) suggests a deliberate strategy, is one that is intended and then realised. In contrast, an emergent strategy (Figure 16) is not an intended strategy, rather the intended strategy is not realised, and another strategy emerges that is better, and this is realised.

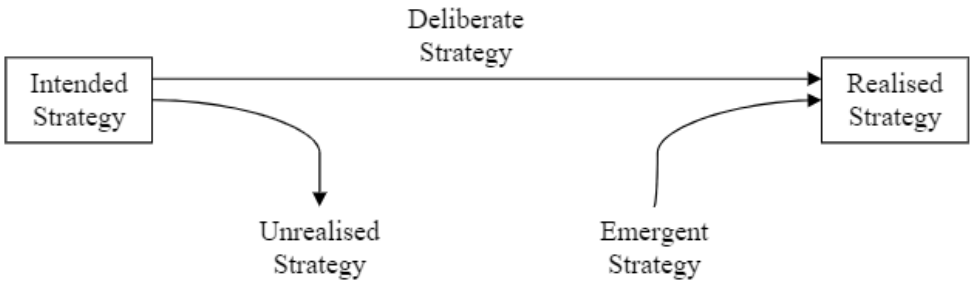

Figure 16 Formulation of deliberate and emergent strategies (Adapted from Mintzberg, 1987).

The strategy formulation process used by the case farmer is similar to that reported in the empirical farm management literature by Beijeman et al. (2009). Beijeman et al. (2009) reported that dairy farmers identified new strategies by either monitoring their external environment directly or using their social networks. The dairy farmers in Beijeman et al.'s (2009) study also purposefully searched for new strategies via industry links, maintaining strong social networks within and outside of the dairy industry and keeping up to date with various information sources. The case farmer purposefully researched the water reticulation strategy through a local consultancy firm's report on the benefits of water reticulation systems and discussed the strategic options with his immediate social network (e.g., equity partner and director). During the formulation of the investment strategy, the case farmer used a financial budgeting technique (e.g., implementation test (Beijeman et al., 2009; Chapman et al., 2007)) to validate his intuition and to forecast the probable outcomes and consequences of adopting the new strategy into the farm business. The analytical techniques used by the case farmer have been reported in studies by Beijeman et al. (2009) and Chapman et al. (2007). They also reported that the farmers in their studies used these techniques to assess and forecast the probable outcomes and consequences of strategic options as well as to test the practicality and viability of such strategies. The following section describes the case farmer's strategy implementation and control process.

5.7. The case farmer's strategy implementation and control process

Once a new strategy is formulated, the case farmer initiates its implementation. Due to uncertainty, the case farmer must also control the implementation of the strategy. This involves monitoring the implementation process and evaluating the information provided by his monitoring system. This is similar to the implementation and control processes in the strategic management literature (Gray, 2005; Martin & Shadbolt, 2005), the implementation and consolidation processes in Sutherland et al.'s (2012) "Triggering Change" cycle, the response and feedback stages in Risbey et al.'s (1999) model of decision-making framework for adaptation, and the implement, monitor, evaluate and adjust steps in Williams et al.'s (2009) adaptive management process. The case farmer used both concurrent and historical control in relation to managing the implementation of the water reticulation system. In terms of concurrent control, the simplest role was to determine when the next activity in the strategic plan needed to be initiated, as reported by Gray

(2005). Examples of this were the sequencing of when blocks of paddocks were connected to the new reticulation system. At a more complex level, concurrent control was used to manage the upside and downside risk that impacted on the strategic plan at the tactical and operational levels. In terms of historical control, the case farmer was monitoring key factors to assess if the strategy was performing as expected and to also assess if it needed to be adjusted or dis-adopted. The case farmer's strategy implementation and control process comprises of two steps: 1) implementing the strategy to adapt to the change and 2) the monitoring and evaluation of the implemented strategy. Each of these steps will be discussed in the following sub-sections.

5.7.1. Implementing the strategy to adapt to the change

The investment strategy of a new reticulated water system that was highlighted in the previous stage was chosen to be implemented within the farm system. Such strategy commits the case farmer to undertaking a capital investment (e.g., new reticulated water system). During strategy implementation it also involves the case farmer organising the necessary resources that will support successful strategy implementation (Martin & Shadbolt, 2005). The process used by the case farmer to organise the resources required for the new reticulated water system involved utilising the financial budget which details the expense of the capital investment and purchasing the necessary materials (e.g., tanks, pumps, pipe, valves, concrete water troughs etc) required for its implementation. The case farmer also had to organise a loan through his local bank to fund the investment. The case farmer utilised AgFirst Water Engineering to assist with setting up the tanks and pumps which sit in a good position to adequately deliver water across the farm. The water scheme has been implemented in stages and is ongoing due to it being a large capital investment. The case farmer and on-farm employees including the shepherd and general farm hand are continuing to position troughs in each paddock and run water pipe to ensure every paddock on the farm has fresh clean water to thus increase the grazing flexibility across the property. The case farmer suggests *"the water scheme we've put in is quite a big strategy for building a resilient system, especially when you have good clean drinking water stock do remarkably well, and if they haven't got a lot to eat, I think this that will allow us to take another step".*

The strategy that has been implemented is similar to those discussed in the literature review, whereby strategy implementation commits a farmer to undertaking one or more of the following actions including: 1) changing management practices (Sutherland et al., 2012), 2) changing the use of inputs, 3) changing the output mix (e.g., sheep and beef) (Cowan et al., 2012), and 4) undertaking a capital investment (Gray et al., 2009; Gray et al., 2011; Lieffering et al., 2012). The importance of infrastructure such as reticulated water systems in drought-prone areas has been reported in the farm management literature. For example, Gray et al. (2011) in a catchment study of 24 East Coast farmers reported that farmers identified water supply as an important infrastructure element in enhancing their drought resilience. Although strategy implementation is identified as an important step in the strategic management and adaptation processes (Martin & Shadbolt, 2005; Nell & Napier, 2005; Risbey et al., 1999; Sutherland et al., 2012; Williams et al., 2009), little is

written about this function of management in the farm management literature. As such, this study provides some insights into this step within the adaptation process. Martin and Shadbolt (2005) stated that implementation is often the under-rated step in strategic management, but it is often the reason that strategies are ineffective. They went on to say that this was not normally due to strategy formulation, but rather its execution. Beijeman et al. (2009) reported that the New Zealand dairy farmers in their study demonstrated six different strategy implementation sequences. One of these reported was that the intended strategy was implemented successfully without being influenced by other intended or emergent strategies, which is similar to the implementation sequence carried out by the case farmer, however such intended strategy was realised. Once the strategy has been implemented appropriately within the farm system, the case farmer monitors and then evaluates the implemented strategy using his control process. Such process in described in the following section.

5.7.2. The case farmer's control process

The control process for the new water reticulation strategy involved the case farmer monitoring a range of factors that were used to: 1) implement the strategy, 2) manage uncertainty as the plan is implemented, and 3) evaluate the strategy. These steps are similar to those in the strategic management literature (Gray, 2005; Martin & Shadbolt, 2005). In Risbey et al.'s (1999) normative model of the adaptation process, the "Feedback" step is similar to control. Riseby et al. (1999) did not identify the role of monitoring in relation to implementation and the management of uncertainty during strategy implementation. Sutherland et al.'s (2012) "Triggering Change" cycle also only focused on strategy evaluation. The following section will describe the monitoring and evaluation processes used by the case farmer in relation to the new water reticulation strategy.

5.7.3. The monitoring and evaluation of the implemented strategy

The case farmer uses an ongoing and continuous process to monitor the implemented strategy. The first set of factors that the case farmer is monitoring is the progress of the implementation of the new reticulated water system against the initial plan. Because the plan is sequenced over several years and involves the installation of the new reticulation system in different blocks of paddocks over time, the monitored information tells the case farmer when one block is finished and when the next block in the plan can be initiated. The case farmer used his monitoring system to control plan implementation as reported by Gray (2005). The case farmer is also monitoring factors to manage uncertainty around the implementation and use of the new water reticulation system. This included identifying any holdups in the installation of the system and the tactical use of the new system during the summer in terms of where he is grazing stock. For the latter, the case farmer was monitoring the distribution of feed across the farm relative to the blocks that had the new water reticulation system. The final information he is monitoring is the information that he uses to assess the effectiveness of the strategy. The new water reticulation system aims to improve animal health, stock performance and grazing flexibility across the entire property to reduce underutilization of pasture. It

also aims to reduce the stocking systems vulnerability in drought as they will have access to clean water which is vital for animal health and survival. Here he is monitoring a wide range of factors and then comparing these against his expectations that had been developed in the planning process. For the new reticulated water system, this included the quality and reliability of the water supply over time, and particularly during the summer period. He is also monitoring the impact of the new reticulated water system on stock health and performance, and how it influences his ability to utilise feed during dry periods.

The role of monitoring in the control process is similar to that reported by Gray (2005). Although Sutherland et al. (2012) stressed the importance of evaluation in the "Consolidation" phase of his "Triggering Change" cycle model of adaptation, he did not report on what factors farmers monitored to undertake such as an evaluation. The case farmer evaluated his new water reticulation strategy by comparing its performance against his expectations of its performance developed in the strategic plan. He expected that it would improve the animal health and performance of his stock and his grazing flexibility, particularly over summer and during droughts. However, in this case the farm system has not been exposed to harsh summers or drought in the previous three years during the implementation of the water reticulation system. Rather the farm system has experienced wetter than usual summers. Therefore, the case farmer has not been able to fully test the capability and effectiveness of the new water reticulation system under drought conditions, or to observe the influence that clean stock water has on stock performance and animal health during these conditions. The case farmer also compared the actual cost of the reticulated water against the initial plan. As interest rates and inflation have increased over the last few years, the resultant cost of materials has also increased which has meant that the actual cost of the water reticulation system has increased considerably due to several external factors (e.g., Covid-19 pandemic, Ukraine war).

The monitoring and evaluation process used by the case farmer is a similar process to that described by Gray (2005), and Martin and Shadbolt (2005) in the strategic management literature. It is also similar to the "Monitor" and "Evaluate" steps in Williams et al.'s (2009) adaptive management model, the "Feedback" stage in Risbey et al.'s (1999) adaptation model, and the "Consolidation" phase of Sutherland et al.'s (2012) "Triggering Change" cycle model of adaptation. As with Gray (2005), this study showed that control aims to manage the implementation of the plan, minimise the impact of uncertainty on plan implementation and evaluate the effectiveness of the new strategy or strategic plan (Gray, 2005). The final stage in Risbey et al.'s (1999) adaptation process is "Feedback", which involves monitoring the outcomes of the decision to implement a new strategy to assess whether it performs as expected. Similarly, in Sutherland et al.'s (2012) "Triggering Change" cycle, a key aspect of the consolidation stage was evaluating the success of the farm system after a new practice or structural change had been implemented.

In the case farmer's strategic planning process, he learnt a lot about the impact of reticulated water systems may have on farm performance through reading the consultancy firm's report, talking to other farmers who had such systems, and the agricultural engineers that installed the system. He has gained new knowledge by

implementing the strategy and monitoring its performance against his expectations. Because of this learning, he has a much greater appreciation of the importance of reticulated water in a dryland environment. He has learnt that new infrastructure can improve the farm system's adaptive capacity, but he has also learnt about the benefits of water reticulation systems in a dryland environment and how such systems may enhance the resilience of his farming system via providing grazing flexibility in paddocks that once had minimal to no water. The new water reticulation system is also advantageous in terms of improving water quality management on-farm. However, as a result of experiencing wetter than usual summers, he has been unable to validate his new knowledge (or the strategy) because he has not experienced dry summers or droughts to see if it performed as expected. The evaluation process as reported by Gray (2005) could be used to validate new knowledge once dry summers or frequent droughts occur.

Chapter Six

6. Conclusions

6.1. Introduction

The sheep and beef industry in New Zealand is an important contributor to the national gross domestic product and an important driver of economic growth in the regions (Beef and Lamb New Zealand, 2018, 2021b). Hill county farming is an important contributor to the New Zealand sheep and beef industry, as it comprises around 50% of the farms in the sector (Beef and Lamb New Zealand, 2020). Hill country farms in New Zealand are extensive and low input farming systems that comprise of a mixture of flat, rolling, and steep topography. Such systems are sensitive to environmental conditions due to their particularly low inputs of fertiliser and purchased feed which impacts their profitability and sustainability (Beef and Lamb New Zealand, 2020). Hill country farms produce lambs and cattle either prime for slaughter or sold as store. Although hill country farms play an important role in the New Zealand economy, there is growing concern that these farms are facing an increasingly turbulent external operating environment (Chappell, 2019; Gray et al., 2011). This is particularly the case for farms on the East Coast of the North Island including the Gisborne, Hawkes Bay, and Wairarapa regions which have experienced a long history of extreme weather events such as ex-tropical Cyclone Bola in March 1988. Over the last decade, these regions have experienced both droughts and intense rainfall events (Chappell, 2019a).

East Coast hill country sheep and beef farmers are facing increasing change in their operating environment due to the long-term stressor known as climate change. Climate change is likely to exacerbate the level of climate variability and increase the intensity, severity, and frequency of adverse weather events (e.g., ex-tropical cyclones and drought) on the East Coast (Chappell, 2019; Ministry of Environment, 2017; National Institute for Water and Atmosphere Research, 2020a). To cope with changes in their operating environment in relation to climate change, farmers need to develop adaptive capacity (Darnhofer., 2021; Gray et al., 2011; Nicholas-Davies et al., 2021; Shadbolt et al., 2013). However, little is known about the adaptive capacity of New Zealand farmers and limited research has been undertaken into the adaptive capacity of East Coast Hill country farmers in relation to climate change. There is limited understanding about the process used by farmers to identify change in the environment or the process they use to adapt their farming system to cope with such change. Identifying, resilient farmers that are recognised as having high adaptive capacity and describing how they are adapting their farming systems to cope with climate change would provide valuable knowledge for the sheep and beef sector going forward. Such a study would provide insights into the processes and the strategies that other hill country sheep and beef farmers on the East Coast could use to better cope with climate change.

This research set out to answer one important research question related to adaptive capacity:

How does a farmer with high adaptive capacity identify change in the environment in relation to climate change and then adapt their farm system to cope with this?

This chapter sets out a summary of the key findings from the explorative case study in Section 6.2. Section 6.3., provides an evaluation of the method and Section 6.4., discusses the implications that flow from the findings from the study. The final section (6.5) outlines future research that could be undertaken to build on the findings from this study.

6.2. A summary of the key findings from the study

This explorative case study identified one East Coast hill country sheep and beef farmer that exhibited a high level of adaptive capacity. The case farmer exhibited the five attributes of adaptive capacity including an internal locus of control, sense-making capability, capacity to learn to live with change and uncertainty, strategic thinking and planning capability, and high self-efficacy that were identified in the literature review. The selection criteria based on these attributes were used to provide guidelines to an experienced farm management consultant to select a suitable farmer for the study. The case farmer operates a traditional hill country breeding operation, which is typical for the East Coast of the North Island, and it is in an area that has previously experienced several climatic shocks (e.g., droughts and cyclones) and climate change forecasts suggest the area will have an increased incidence of drought and extreme weather events (Chappell, 2019; Ministry of Environment, 2017; National Institute of Water and Atmosphere, 2020a).

This explorative case study described the adaptation process used by an East Coast hill country sheep and beef farmer with a high level of adaptive capacity. The process used by the case farmer could be usefully separated into three main stages: 1) a sense-making stage where he, a) scans the operating environment for cues that indicate a change, b) identifies a change in the operating environment in relation to climate change, and c) assesses the nature and the impact of the change on his farm system, and 2) a SWOT analysis and strategy formulation stage where he;,a) assesses the opportunities and threats that flow from the identified impacts of the change, b) undertakes an internal analysis and capability assessment to determine if the current suite of strategies can cope with the identified threats and opportunities, and d) on the basis of the previous step, if required, he formulates a new strategy (or strategies) to adapt to the impacts of the change, and 3) the implementation and control stage where he, a) implements the new strategy, and b) monitors and evaluates the implementation of the new strategy. The adaptation process used by the case farmer has similarities with the normative adaptation models in the literature (Riseby et al., 1999; Williams et al., 2009) and the process developed by Sutherland et al. (2012) from an empirical study of major on-farm practice and/or system change by organic and conventional farmers in the United Kingdom. Elements of the process such as stages 2 and 3 are also similar to the normative strategic management process (e.g., Martin & Shadbolt, 2005).

A useful addition to the previous models of the adaptation process is the incorporation of the sense-making concept (Klein et al., 2006a,b; Weick, 1995) and its three sub-processes. This concept is particularly useful because as shown within the study, the case farmer must "make sense" of a complex situation to determine if firstly, climate change is occurring, and secondly, what impact climate change will have on his farming system in the future. The study found that both individual and social sense-making were used as proposed by Klein et al. (2006a,b) and Weick (1995) to scan the operating environment and identify changes in the environment in relation to climate change. As postulated by Risbey et al. (1999), the case farmer used sense-making at different spatial (e.g., farm or local, regional, and global) and temporal scales (e.g., short, medium, and long term) to help inform him about change in the operating environment in relation to climate change. This showed that the farmer used information at the local, regional, national, and global levels to determine if climate change was occurring. Importantly, he also used information across temporal scales including historical trends (on-farm climate data and production data, other farmers' experience, and information), recent climate data and climate forecasts. He triangulated this data across scales to determine if climate change was occurring. The study highlighted that a problematic area for farmers is that once they have determined that climate change is occurring, how do they assess its impact at the local level on their farming system. The case farmer highlighted that aspects of the regional forecasts (declining and more variable summer rainfall) were not reflected in the trends in his on-farm data (increasing summer rainfall). Where the regional forecasts and the on-farm data did not line up, the case farmer preferred to trust his on-farm and local data rather than the regional forecasts. As with other studies (e.g., Hyland et al., 2016; Gandure et al. 2013; Woods et al., 2017), the case farmer perceived that the time scale used in some climate change reports were too far into the future (out to 80 years) to be relevant to his current decision-making.

The study provided new insights into the sense-making process in relation to how farmers determine the impacts of climate change on their farm system. The case farmer extrapolated the changes in climate he had observed on his farm over the last 12 years to determine what he might expect over the next 3 – 5 years. Based on these projections and drawing on his knowledge about his farm system, he deduced the impacts of these changes on the farm system and its performance. This has not been previously reported in the literature. This process supports the work of Klein et al. (2006a,b) in the organisational literature which postulates that the sense-making process enables the individual to make sense of a change and understand the stimuli (e.g., change that is occurring) and its impact before acting upon it through the decision-making process (Klein et al., 2006a).

The study has provided some new insights into the SWOT analysis process postulated in the farm management literature. It identified that once the case farmer had determined the impacts of climate change on his farm system, he then assessed if they had a positive or negative impact on the farm's performance and profitability, a point postulated by Martin and Shadbolt (2005) in the normative strategic farm management literature. On this basis, the case farmer then classified the changes in climate as a threat, or an opportunity

or both. Although the strategic farm management literature (e.g., Martin & Shadbolt, 2005) has postulated how a farmer should undertake an external analysis to identify threats and opportunities, little has been written about how farmers do this in the literature, and particularly in relation to climate change.

The SWOT analysis undertaken by the case farmer in his adaptation process is similar to that proposed in the farm management literature (Martin &e Shadbolt, 2005), but he incorporates a step where he evaluates if his current suite of strategies (and tactics) can cope with the future threats and opportunities he has identified. Once the threats and opportunities associated with climate change over the next 3 – 5 years are identified, the case farmer undertook an internal analysis of the farm system and assessed its capability of mitigating the former and taking advantage of the latter. The internal analysis of the farm system is used to identify the strengths and weaknesses of the farm business that are relevant to the identified threats and opportunities. Martin and Shadbolt (2005) pointed out that the internal analysis could "potentially be very wide-ranging" (p. 103). However, in practice those parts of any particular business should be scrutinised closely will depend on the type of business and the strategic concerns. The case farmer then assesses whether his existing suite of strategies and associated tactics are suitable to mitigate these threats and take advantage of the opportunities. This is an important step as it highlights key similarities to the study by Cowan et al. (2012) who reported that an assessment of a farm system's tactical and strategic flexibility can determine how vulnerable the system it is to weather variability and a changing climate. Similarly, Smit and Wandel (2006) and Adgar (2006) thought that it is useful to understand how vulnerable and exposed a farm system may be to climate change. A typical SWOT analysis in the normative farm management literature does not assess the farm system's capability to mitigate threats and take advantage of opportunities (Martin & Shadbolt, 2005). Rather, the identified opportunities, threats, weaknesses, and strengths are used to develop a small number of strategic choices that will better help the farmer achieve their long-term goals (Martin & Shadbolt, 2005).

The assessment of the existing suite of strategies is an important step in the adaptation process because changes in strategy are normally costly in terms of capital, and/or the time required to plan and implement the strategy, and to develop the human capability to implement the strategy effectively (Sutherland et al., 2012). Thus, if current strategies are robust enough to cope with the impacts of the expected change, it makes sense not to introduce new strategies. Based on the case farmer's internal analysis and capability assessment, he identified several strengths within his system which indicated he had the strategic and tactical flexibility (Cowan et al., 2012) to cope with the anticipated impacts (threats and opportunities) from climate change over the next 3 – 5 years. As such, he did not need to formulate additional strategies to cope with these threats and opportunities. Thus, rather than formulate new strategies to cope with climate change, the case farmer returned to scanning his operating environment to identify further changes in his operating environment, or as Sutherland et al. (2012) reported, when the next "trigger point" occurs. Therefore, he will continue to make sense of the changes occurring in his operating environment until he identifies that his farm system and his suite of strategies are not capable of coping with the increased level of change. This is an

important finding because it suggests that in order to avoid expensive changes to their farm system as a response to climate change, farmers need to first assess the capability of their current buffer capacity to cope with the expected changes in the climate.

To provide some insights into the rest of the case farmer's adaptation process, he was asked about a previous instance where he had formulated new strategies to cope with the expected impacts of climate change. Earlier in his time on the farm, dry summers and drought were a usual occurrence. As such, the on-farm historical climate data was in-line with the climate change forecasts that the East Coast would be warmer and summer rainfall would be less and droughts more frequent. The study has provided some new insights into the strategic management process (planning, implementation, and control) postulated in the farm management literature. The case farmer's process to formulate a new strategy (investment into a new reticulated water system) to cope with the impacts of climate change, and in particular drier summers and more frequent drought, is similar to the process described in the strategic management literature (Martin & Shadbolt, 2005; Nell & Napier, 2005). The case farmer's strategy formulation process involved him undertaking an analysis of the external environment to identify potential opportunities and threats, and then he undertook an internal analysis of the farm resources to identify important on-farm strengths and weaknesses in relation to that threat. He then undertook a creative process, the strategic thinking aspect of strategic management (Duranovich, 2015; Martin & Shadbolt, 2005; Nell & Napier, 2005), to come up with a strategic option (invest in a new reticulated water system) to mitigate the impact of the threat (drier summers and more frequent droughts) and minimise the on-farm weakness (inadequate water supply infrastructure).

The study also obtained some insight into the strategic planning process used by the case farmer. He firstly sought out information and advice from his social networks and other information sources to help him decide whether such strategy was appropriate. This process was also used by the farmers in the study by Beijeman et al. (2009). The case farmer also used a financial budgeting technique to validate his intuition and forecast the probable outcomes and consequences of adopting a new water reticulation system on the farm business. This is similar to the "implementation test" used by farmers in the studies by Beijeman et al. (2009) and Chapman et al. (2007). Based on this implementation test and discussions with the farm business directors, the investment strategy of a new reticulated water system was chosen to be implemented within the farm system. This strategy commits the case farmer to undertaking a capital investment (Gray et al., 2009; Gray et al., 2011; Lieffering et al., 2012) to improve his infrastructure on-farm. A previous study by Gray et al. (2011) highlighted the importance of infrastructure improvements such as the investment in new reticulated water systems are particularly important in drought prone areas.

Strategy implementation involves the case farmer organising the necessary resources to complete the new water reticulation system as proposed by Martin and Shadbolt (2005). This study provided some insights into the implementation process. It involved organising the finance for the investment with his bank, purchasing

the necessary materials (e.g., tanks, pumps, pipe, valves, concrete water troughs etc.) and organising the farm staff and the local agricultural engineer to install the tanks, pipelines, and pumps to deliver water across the farm. The water scheme has been implemented in stages to spread the capital outlay. As such, the case farmer also had to organize the sequencing of the process over time in terms of finance, the purchasing of the materials and the organization of labour, machinery, and input from the agricultural engineer. Although strategy implementation is identified as an important step in the strategic management and adaptation processes (Martin & Shadbolt, 2005; Nell & Napier, 2005; Risbey et al., 1999; Sutherland et al., 2012; Williams et al., 2009), little is written about this function of management in the literature.

The control process for the new reticulated water strategy involved the case farmer monitoring a range of factors that were used to: 1) implement the strategy, 2) manage uncertainty as the plan was implemented and 3) evaluate the strategy. The case farmer used his monitoring system to control and therefore manage plan implementation as reported by Gray (2005), and this was either based on dates from his plan triggering activities or the completion of one activity initiating the activation of the next activity in the plan. In terms of managing uncertainty, this included identifying any holdups in the installation of the system and the implementation of contingencies to deal with this. It also was used at the tactical level during the summer to monitor the distribution of feed across the farm relative to the blocks that had the new water reticulation system so that the grazing sequence of the stock could be adjusted to make best use of the new reticulated water system. Such control process involved using concurrent and historical control in relation to managing the implementation of the water reticulation system, which is similar to that reported by Gray (2005).

Monitoring played an important role in strategy evaluation. In effect, the case farmer compared the performance of the system and actual cost of the investment against his expectations that he had developed during the planning process, which is similar to the process reported by Gray (2005). He expected the new water reticulation system to improve animal health, stock performance, grazing flexibility, and pasture utilization over the summer period. He also expected it to reduce the farm system's vulnerability to drought by providing access to clean water which is vital for animal health and survival. Since the implementation of the new water reticulation system, the farmer has had a series of wetter than usual summers, so he has not been able to assess the effectiveness of the new strategy. As such he has not seen any immediate improvements to animal health, particularly during summer. This highlights the problems farmer face in making investments based on longer term forecasts and the uncertainty around such forecasts.

The case farmer's strategic planning process has enabled him to learn about the impact of reticulated water systems on farm performance through 1) reading the consultancy firm's report on this and 2) talking to other farmers who had such systems and the agricultural engineer that installed the system. As such, he has enhanced his knowledge about the benefits of reticulated water and now has a greater appreciation of the importance of reticulated water in a dryland environment. However, he has not validated the new knowledge (or the strategy) because he has not experienced dry summers or droughts to see if it performed as expected.

6.3. Evaluation of the method

The single explorative case study method used for this research was appropriate to address and inform the research question. However, based on an evaluation of the method, such research should be interpreted in a manner that does not disregard what worked well, what did not, and how the research method could be improved. As such during the early stages of the research process, the first experienced farm management consultant that the researcher contacted was found to have little understanding about the term adaptive capacity and little theoretical knowledge about the subject area of climate change adaptation. This resulted in them recommending farmers that were unsuitable for the study. As such, other local farm management consultants had to be approached to find a suitable case farmer. Therefore, if this study was to be repeated, the author would recommend that the researcher spend more time with and provide additional resources to the farm management consultants about the type of farmer that is required for the study and the behaviours one would expect from farmers with high adaptive capacity. This would increase the likelihood that the farm management consultants will select suitable case farmers for the study.

Another lesson that was learnt from the study is that a researcher should consider the seasonal demands on a case farmer's time and plan the interviews and farm visits accordingly. This was a problem with this study and the interviews were spread over the period from July 2022 to February 2023, respectively. Travel to the case farm was also a consideration in terms of cost and time. This could be improved by choosing a case farmer that resided in close proximity to the researcher's location.

The attributes relating to high adaptive capacity that were identified through the literature review were used as a guide for selecting the case farmer, but these attributes were not measured. An alternative approach would have been to ask the consultant to identify a range of farmers with high adaptive capacity based on this selection criteria and then develop a quantitative instrument to measure each attribute of adaptive capacity so that an objective score could be used to assess the farmer with the highest level of adaptive capacity. This would involve assessing each of the farmer's attributes for self-efficacy, internal locus of control, sense-making capability, strategic thinking and planning capacity and their capacity to learn to live with change and uncertainty. Because of the complexity of the adaptation process, in hindsight, the researcher could have benefited from additional support and guidance in terms of the interview process and the use of probing questions to bring out more depth in the interviews.

6.4. Implications for this research

This explorative case study highlighted some implications for several groups. Firstly, the study highlighted some important points for the National Institute of Water and Atmosphere (NIWA) and other organisations that put together climate change forecasts such as Beef and Lamb New Zealand, and the Ministry for Primary Industries (MPI).

- First, if farmers are required to make changes to their farm strategy, these are often costly in terms of capital and time, and also the time required for farmers to build capacity and capability. This study, and the literature has shown that farmers do not see long term climate forecasts as relevant to them for such decision-making. They are too far into the future to be relevant. As such, organisations that provide climate change forecasts for farmers need to use time frames that are relevant to farmers.
- Second, this study has shown that the case farmer uses a wide range of scales to get an idea about whether climate change is occurring. On a spatial scale, this can range from on-farm to the local district, regional, the national scale and on a global scale. They also look at different temporal scales – historical trends, current trends, and longer-term trends. If information provided from this range of scales suggest that climate change is happening, they then need to translate all this data into what impacts this will this have at the farm level scale and for time scales of around 3 – 5 or 5 – 10 years. Current reports tend to be at the regional scales and for prolonged time periods (out to 30 – 80 years). Farmers need information that is specific to their local scale and as stated in the previous paragraph, more in line with their shorter-term planning horizon.

The second group that findings from this study has some implications for include hill country sheep and beef farmers, Beef and Lamb New Zealand and farm management consultants. Such findings could also arguably be relevant to other sectors such as dairy, horticulture and/or arable. This study has shown that it is difficult to make sense of climate change data because it is available at different scales and provided by different sources. Farmers would benefit from advice on how to make sense of what is happening in their environment in relation to climate change. Such advice could be provided by Beef and Lamb New Zealand through field days and workshops. Similarly, farm management consultants could be trained in this process which they could use with their clients.

This study has also highlighted that an important step in the adaptation process is the assessment of the capability of a farmer's current strategies and tactics to cope with the expected threats and opportunities arising from climate change. That is an assessment of whether, or not a farmer's farm system is vulnerable to the changes in the environment due to climate change. The adoption of new strategies is a costly process (time and capital), so this an important skill for farmers going forward. Beef and Lamb New Zealand could run an extension programme with workshops for farmers on how to assess if their current strategies and tactics can cope with the expected changes in their local climate due to climate change. Similarly, farm management consultants could be trained in this process so that they could use it with their clients.

This study has also highlighted that strategy formulation to cope with the threats and opportunities associated with climate change is a complex process. Beef and Lamb New Zealand could provide workshops for farmers on how to formulate effective strategies for climate change – the process, the types of strategies they might use, the costs and benefits as well as the pros and cons of different strategies. Farm management consultants could be trained in this process so that they could use it with their clients.

6.5. Future research

From this study, a range of future research areas have been identified in relation to adaptive capacity and climate change. Although several key attributes in relation to a high level of adaptive capacity were identified from the literature, these were not quantitatively measured for the case farmer. Future research could use these attributes and measure the adaptive capacity of a cross-section of hill country farmers to assess their adaptive capacity. Following on from such a study, a similar approach could be used to compare farmers with low and high adaptive capacity and determine if there are differences in the suite of strategies and tactics these farmers utilise on-farm within their agribusiness. An interesting study would be to look at the difference in farm financial performance between farmers with low and high adaptive capacity over time to determine if these differences in adaptive capacity are reflected in their farms' long-term financial performance.

This study was based on a single-case study design. Future research could use a multiple-case study design to compare, and contrast farmers with a high adaptive capacity. Such a study might look at hill country farmers from a single region such as the East Coast of the North Island, or they might look at farmers from across different regions to see if regional differences exist. Alternatively, the study could look at different types of farmers such as sheep and beef farmers and dairy farmers. A multiple case study could be used to obtain an in-depth comparison between farmers with high adaptive capacity and those with a low adaptive capacity. This study could be enhanced by also collecting long-term financial performance data on each case.

To improve the knowledge about farmers adaptive capacity and climate change adaptation, further research could be undertaken into at least four other related areas including:

a) Understanding the motives and/or barriers to climate change adaptation

Given that this current study focuses on the adaptation process used by a farmer with high adaptive capacity, a similar methodology could be used to explore the motives and/or barriers to climate change adaptation. The collection of financial information would be useful to determine whether the farmers' financial capacity prevents them from investing in new strategies to mitigate or take advantage of climate change. Such a study may also outline key behavioural traits that help to explain a farmer's capacity to adapt with respect to how their personality, values and skills influence their decision-making processes.

b) A case study of a farmer with high transformability

The literature suggests that farmers will face an increasingly turbulent operating environment. As such, farmers will not only need a high level of adaptive capacity, but they may need a high level of transformability (Walker et al., 2004). Further research could be undertaken to understand a farmer's transformability capacity, particularly after a major shock event (e.g., ex-tropical cyclone). A plausible option could be to explore the extent and nature of shock events, and the impact they have on livelihood and financial viability. It could also look at a farmer's motivations towards transforming their farm system after it

has reached a particular tipping point (Walker et al., 2004). This could be carried out in qualitative manner using explorative case studies of farmers or growers who have transformed their farm or horticultural system after a severe shock or change in the environment.

c) Understanding how the government's policy on greenhouse gases and climate change influence on-farm mitigation and adaptation

As a farmer's operating environment becomes increasingly regulated by the New Zealand government to reduce greenhouse gas emissions through mitigation options, an area of research that should be considered is the influence and role that government policy on greenhouse gases and climate change plays within a farmer's decision-making process. A plausible option would be to undertake qualitative research with several East Coast hill country sheep and beef farmers to explore their perception toward such policy and how it impacts farmers' livelihoods. It would also be appropriate to explore to what extent do farmers understand the regulations set by the government and whether climate change policy is enforcing involuntary mitigation and adaptation.

d) Understanding how farmers make sense of information received from different sources and at different scales (spatial and temporal)

An important issue in relation to adaptation, is how do farmers make sense of the information they are receiving from different sources and at different scales (spatial and temporal). Such information may provide conflicting results. It would be appropriate to undertake qualitative research with several East Coast hill country sheep and beef farmers to explore how they utilise such information and how they translate this to determine what will happen in terms of the impacts of climate change at their local scales on-farm. It would also be beneficial to understand what information sources are the most useful for farmers and to explore what other information may aid sense-making efforts.

This study gave insights into the case farmers adaptation process, but each of the steps in the case farmer's adaptation process could be explored in a lot more detail to provide greater insights into the adaptation process. As with earlier suggestions, this could be within or across farm types, within and across regions, and between farmers with low and high adaptive capacity.

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8. Appendices

8.1. Appendix I: Selection process interview questions

Aim: To identify an East coast farmer with high adaptive capacity.

Climate change awareness and adaptation process

The following questions are concerned about your awareness and perception of climate change and if you believe it is having an impact on your farming system.

1. Firstly, do you think the intensity, frequency, and severity of extreme weather events such as drought, intense rainfall and ex-tropical cyclone events have increased or decreased in your farming area?

2. Would you say this is a result of climate change itself or just normal seasonal weather variability? How have you come to this conclusion?

3. What are some significant climate change effects on farm that you have been observing in the last 5-10 years?

4. How would you describe the nature of these changes impacting your farming system? i.e., low, moderate, high, severe/extreme, unpredictable etc.

5. Is the nature of change that you are experiencing at the farm level in relation to climate change extreme enough to require adaptative measures/strategies?

6. If so, what is your current position in terms of implementing adaptations? Are you thinking of adapting your system, currently adapting your system or have you already adapted your system since identifying significant changes that were affecting your farming system because of climate change?

Networks and information gathering

These questions are concerned with your networks and what sources you use to find information about climate change.

1. Who are the people you network with to help you with decision-making/advice around climate change?

2. What sources do you use to find useful and credible information about climate change?

Strategic thinking/planning and core capabilities/abilities

The following questions are concerned with your strategic thinking/planning ability as well as other core capabilities/ abilities that are associated with high adaptive capacity.

1. Do you consider yourself to have a high ability to manage and cope with climate change and associated shocks such as drought or flooding events?

2. In terms of strategic and tactical flexibility, how have you built in flexibility into your farm system to cope with changes in relation to climate change?

3. Do you use strategic planning as a part of your farm management approach? Do you use any technologies to help you with this process i.e., Farmax etc.

4. Do you use any technology or applications on farm to help you manage at the operational and tactical level? i.e., FarmIQ, weather monitoring stations etc.

5. Do you consider yourself to have the self-confidence to control the impacts of climate change through your farm management approach?

Education and training

The following questions are concerned with your education and training.

6. Years of experience farming?
7. What is your highest level of education?

8. Have you participated or been involved in other industry training courses?

9. Are you currently undertaking any education or training to upskill and improve your learning abilities?

Farm system information

The following questions are concerned with your farm system.

10. How many properties does your farm business operate on? i.e., your geographical distribution (summer dry farm and farm in a summer wet area or a breeding and finishing farm)

11. How many staff do you employ on farm?

12. Of those you employ on farm, what type of training or qualifications do they hold?

13. Of those involved in the family farm, do any of these people have off farm employment?

14. How many different enterprises do you operate in your farm business?

Sheep	
Beef (Traditional breeding)	
Finishing	
Trading	
Dairy support	
Other (Honey etc)	
Orchards/Horticulture	

Please specify any others.

15. Do you have any riparian, manuka, forestry, QEII covenant blocks, poplar pole planting or wetlands situated on your farm?

Farm system information

Location	Nearest town	
	Region	
Climate	Annual Rainfall	
Total Farm Area/Effective Area		
Altitude – low/high and average		
Contour – in pasture/forage Flats (ha) Rolling country (ha) Steep country (ha)		
Beef and Lamb NZ Land Class	Hard hill country	Hill country
Pasture types and quality High fertility pastures (ha) Moderate fertility pastures (ha) Low fertility pastures (ha) Specialty pastures – types and areas (ha) (this includes lucerne, chicory and plantain) Arable & Forage crops (ha)		
Soil types/Area		
Drainage or irrigation Type/Area		
Basic Soil fertility (Basic pH, Olsen P) How often do you get soil test?		
Lime applications/year		
Fertiliser applications/year Maintenance fertiliser Nitrogen use/other fertiliser.		
Main Farm Infrastructure (Houses, yards, sheds, fencing and tracks) Number of paddocks and subdivided Water supply – system, quality of water, reliability of water		
Supplementary Feed Reserves		
Grazing blocks? Area		

Sheep enterprise

Possibly request stock reconciliation if available.

Number of Sheep (Stock numbers) 5 & 6 year ewes MA ewes 2 Tooths Ewe lamb > Hoggets Ram Hoggets	
Breed	
Mean lambing date	
Mean weaning date	
Breeding ewes lambing weight	
Breeding ewes' replacement rate	
Flock lambing %	
Hogget lambing %	
Production of greasy wool in kg/SSU	
Average carcass weight (kg)	Prime Store

What is your selling policy for your sheep enterprise? (i.e., sell all lambs store at weaning, sell a mix of store and prime lambs, finish all lambs prime)

Beef cattle enterprise - Traditional breeding herd

Number of beef cattle (Stock numbers) R1 (Heifers) R1 Bulls Bull Calves MA cows MA Bulls (breeding purposes) or AI?	
Breed	
Mean calving date	
Mean weaning date	
Breeding cows calving rate	
Breeding cows' replacement rate	

What is your selling policy for your beef enterprise?

Beef trading/finishing policy/ Dairy beef/ Dairy support?

8.2. Appendix II: Preliminary information sheet

School of Agriculture and Environment
Private Bag 11222
Palmerston North 4442

Project title: "An explorative case study of an East Coast hill country sheep and beef farmer in New Zealand: adapting to cope with a changing climate".

Information sheet

Researcher Introduction

My name is Sonia Hollands, and I am currently undertaking a Masters of Agribusiness at Massey University. My research project entitled "An explorative case study of an East Coast hill country sheep and beef farmer in New Zealand: adapting to cope with a changing climate" aims to identify a farmer with high adaptive capacity and describe the characteristics, drivers, and motives of a highly resilient East Coast farmer with high adaptive capacity. It also aims to explore the process a farmer with high adaptive capacity uses to identify changes in the environment in relation to climate change as well as the process used to adapt their farming system to cope with this change. This project is under supervision of Dr David Gray, Associate Prof Peter Tozer and Prof. Nicola Shadbolt from the School of Agriculture and Environment.

Project Description and Invitation

This explorative case study will provide an in-depth analysis of the process that you (the farmer) use to identify changes in the environment in relation to climate change and how you determine the nature of such change. It also involves exploring the process you use to adapt your farming system to cope with this change, with particular emphasis placed on the strategies and associated tactics that you use on-farm to mitigate and/or take of advantage of such changes. I invite you to participate in this research project, whereby participation is completely voluntary.

Participant Identification and Recruitment

For this explorative case study, you have been identified by a selected regional farm consultant on the East Coast of New Zealand as being a highly resilient hill country sheep and beef farmer who has a high level of adaptive capacity. Based on meeting this selection criteria, your contact details were provided and passed on to me so that I could recruit a suitable farmer for this research project. As such your input is highly valuable to this study. This preliminary interview will be used by me to select a suitable case farmer for the study. The interview will be used to obtain sufficient information to identify the most suitable farmer for the case study because unfortunately I only have time to investigate one farmer in-depth for this study. The following sections set out the research process you will be involved in during the selection phase of the study.

Project Procedures - Selection Process

Firstly, the selection process will be in the form of a semi-structured interview. The preliminary interview is expected to take 30-45mins. With your consent, the interview will be voice recorded. Recordings and your answers are confidential. Personal details such as your name and address will remain anonymous throughout the study. The interview covers a range of topics including, your networks and information gathering, climate change awareness and perception, strategic thinking/planning, education and training, and general farm system information. A short farm tour may also be requested; however, this is greatly dependant on your time availability. In the case that you are not selected as the most suitable farmer for this study, data

collected from this interview will be safely disposed of. You are free to request this data also if you wish. In the case where you are selected as the most suitable farmer, another Information sheet will be provided with more information on the remainder of the research process.

Participant Rights

Completion of this semi-structured interview implies consent to participate. You are under no obligation to accept this invitation. If you decide to participate you have the right to:

- decline to answer any questions.
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name, address, or any personal information will not be used unless you give permission to the researcher.
- be given access to a summary of the project findings when it is concluded;
- ask for the audio recording to be turned off at any time during the interview.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research. If you have any concerns or questions that you wish to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanehtics@massey.ac.nz.

If you have any queries about this interview, please contact me via email ([redacted]) or phone me on [redacted] and I will get back to you as soon as possible. If you have any other concerns or questions about the research, participants are also welcome to contact the supervisors: Dr David Gray via Ph: 06 3569099 ext. 84805 or Email: D.I.Gray@massey.ac.nz or Associate Prof Peter Tozer via Ph: 06 9517795 or Email: P.Tozer@massey.ac.nz

Thank you for your willingness to participate in this research project, it is very much appreciated.

Sonia Hollands

8.3. Appendix III: Research process information sheet

School of Agriculture and Environment
Private Bag 11222
Palmerston North 4442

Project title: "An explorative case study of an East Coast hill country sheep and beef farmer in New Zealand: adapting to cope with a changing climate".

Information sheet

Researcher Introduction

My name is Sonia Hollands, and I am currently undertaking a Masters of Agribusiness at Massey University. My research project entitled "An explorative case study of an East Coast hill country sheep and beef farmer in New Zealand: adapting to cope with a changing climate" aims to identify a farmer with high adaptive capacity and describe the characteristics, drivers, and motives of a highly resilient East Coast farmer with high adaptive capacity. It also aims to explore the process a farmer with high adaptive capacity uses to identify changes in the environment in relation to climate change as well as the process used to adapt their farming system to cope with this change. This project is under supervision of Dr David Gray, Associate Prof Peter Tozer and Prof. Nicola Shadbolt from the School of Agriculture and Environment.

Project Description and Invitation

This explorative case study will provide an in-depth analysis of the process that you (the farmer) use to identify changes in the environment in relation to climate change and how you determine the nature of such change. It also involves exploring the process you use to adapt your farming system to cope with this change, with particular emphasis placed on the strategies and associated tactics that you use on-farm to mitigate and/or take of advantage of such changes. I invite you to participate in this research project, whereby participation is completely voluntary.

Participant Identification and Recruitment

For this explorative case study, you have been identified by me during the selection process as the most suitable farmer for this study. You have met the criteria as being a highly resilient hill country sheep and beef farmer who has a high level of adaptive capacity based on the information collected from the selection process. I believe you will provide quality information and data that is highly valuable to achieving the objectives of this study.

Project Procedures and Research Process

As the most suitable case farmer for this study, more in-depth investigations into your processes you use on farm will be explored. The following information will explain what is involved in this research process. Like the selection process, the research process will also be in the form of semi-structured interviews. This process will involve several interviews which are expected to take 1.0 to 1.5 hours. At this stage 2-3 interviews may be required, with further interviews to be confirmed if required. With your consent, the interviews will be recorded. Recordings and your answers are confidential. Personal details such as your name and address will remain anonymous throughout the study. The research process will cover more in-

depth analysis of your farming system and will cover a range of topics including climate adaptations and, strategic and tactical farm management.

Topics that are expected to be covered in the interview include: (some may have been covered in the selection process already)

- Awareness and perception of climate change
- Process of identifying change and the nature of such change
- Decision-making process for developing a suite of strategies and tactics
- Mitigation and adaptation strategies/tactics that you are implementing or thinking of implementing in your farming system

Data Management

Interview recordings will be qualitatively analysed and are for the use of the researcher(s) only. Information from the interview will be utilised in the final research document. Data will be analysed collectively so that no person can be identified and securely stored for five years. After five years the data collected for this project will be disposed of. A summary of the final project will be available to the participant on request.

Participant Rights

Completion of this semi-structured interview implies consent to participate. You are under no obligation to accept this invitation. If you decide to participate you have the right to:

- decline to answer any questions.
- withdrawal from the study (please provide at least 2 weeks' notice in order for me to find another case farmer)
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name, address, or any personal information will not be used unless you give permission to the researcher.
- be given access to a summary of the project findings when it is concluded;
- ask for the audio recording to be turned off at any time during the interview.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research. If you have any concerns or questions that you wish to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanehtics@massey.ac.nz.

If you have any queries about this interview, please contact me via email ([redacted]) or phone me on [redacted] and I will get back to you as soon as possible. If you have any other concerns or questions about the research, participants are also welcome to contact the supervisors. Dr David Gray via Ph: 06 3569099 ext. 84805 or Email: D.I.Gray@massey.ac.nz or Associate Prof Peter Tozer via Ph: 06 9517795 or Email: P.Tozer@massey.ac.nz

Thank you for your willingness to participate in this research project, it is very much appreciated.

Sonia Hollands

8.4. Appendix IV: Participant consent form

School of Agriculture and Environment
Private Bag 11222
Palmerston North 4442

Project title: "An explorative case study of an East Coast hill country sheep and beef farmer in New Zealand: adapting to cope with a changing climate".

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read, or have had read to me in my first language, and I understand the Information Sheet attached as Appendix I. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time.

1. I agree/do not agree to the interview being sound recorded.
2. I wish/do not wish to have my recordings returned to me.
3. I wish/do not wish to have data placed in an official archive.
4. I agree to participate in this study under the conditions set out in the Information Sheet.

Declaration by Participant:

I _____hereby consent to take part in this study.

Signature: _____ Date: _____

8.5. Appendix V: Values Exercise

The basis for determining value-based leadership.

Designed by Nicola M Shadbolt, Professor in Farm & Agribusiness Management, Massey University

Ruth Gasson, who is a lady with a lifetime of experience with farming families as a farmer's daughter, a farmer and as an academic, developed a list of the most common values she has observed in such families. Although this list was drawn up some thirty years ago it has stood the test of time and is still used by many academics and other professionals when working with farming families worldwide. Ruth's definition of values is:

> "*...a more permanent property of the individual, less liable to change with time and circumstances. A value is a conception of the desirable referring to any aspect of a situation, object or event that has a preferential implication of being good or bad, right or wrong. Values are felt to be justified by reason, moral or aesthetic judgements. ...Values are ends in themselves, pursued for their own sake. They serve as standards influencing the selection from among available modes, means and ends of action*."

This exercise has been developed to see how you rank the values she has drawn up. If you think there is something that is important to you missing in her list, write it down and use it after the exercise when you develop your own value statements.

Procedure Part 1: Values exercise provided to the case farmer.

Step 1: Take a value sheet for each person in the business

Step 2: Circle the number that matches your thoughts on each value – number one is **least** important and five is **most** important to you.

	Values	**Level of Importance**				
		1	**2**	**3**	**4**	**5**
1	Expanding the business					
2	Gaining recognition, prestige as a farmer					
3	Feeling pride of ownership					
4	Purposeful activity, value in hard work					
5	Enjoyment of work tasks					
6	Belonging to the farming community					
7	Making satisfactory income					
8	Continuing the family tradition					
9	Preference for a healthy, outdoor, farming life					
10	Gaining self-respect for doing a worthwhile job					
11	Chance to be creative and original					
12	Safeguarding income for the future					
13	Independence, freedom from supervision and to organise time					
14	Maintaining good relations with workers					
15	Working with other members of the family					
16	Exercising special abilities and aptitudes					
17	Making maximum income					
18	Providing congenial working conditions (hours, security, surroundings)					
19	Meeting a challenge, achieving an objective, personal growth					
20	Control in a variety of situations					

Procedure Part 2: Analysing the results of the Values Exercise

Step 3: Add up the scores for each colour - if you have scores of 2,4,4,3,5 for the five yellow values your total score is 18 and the average is 3.6.

The Value Scores of People in your business

Person 1	Person 2	Person 3

It has often been observed that awareness on the part of the farmer/manager of their own values is essential for them to be able to formulate goals. If common goals are going to be developed for a business, it is essential that you are aware of the differences between the values of people in your business. Ruth Gasson created four main categories from her list of values, and these are colour coded in the Table 4.

The four categories and their colour codes are as follows:

- *Business values*: where farming is viewed as a means of obtaining income and security with pleasant working conditions.
- *Social values*: where farming is undertaken for the sake of interpersonal relationships in work.
- *Expressive values*: where farming is a means of self-expression or personal fulfilment.
- *Lifestyle values*: where farming is valued as an activity in its own right.

You have calculated the scores for each of these categories in step 3. To more easily compare between people it can be useful to put the average scores onto the spider graph below.

Step 4: Use these results to discuss points of difference and similarity between the people in your business. Be careful not to be critical of other people's values, instead take the time to think about how any differences should be taken into account in your business.

Table 4 Values Exercise - The four main value categories.

	Values	Level of Importance				
		1	2	3	4	5
1	Expanding the business	-	-	-	-	-
2	Gaining recognition, prestige as a farmer	-	-	-	-	-
3	Feeling pride of ownership	-	-	-	-	-
4	Purposeful activity, value in hard work	-	-	-	-	-
5	Enjoyment of work tasks	-	-	-	-	-
6	Belonging to the farming community	-	-	-	-	-
7	Making satisfactory income	-	-	-	-	-
8	Continuing the family tradition	-	-	-	-	-
9	Preference for a healthy, outdoor, farming life	-	-	-	-	-
10	Gaining self-respect for doing a worthwhile job	-	-	-	-	-
11	Chance to be creative and original	-	-	-	-	-
12	Safeguarding income for the future	-	-	-	-	-
13	Independence, freedom from supervision and to organise time	-	-	-	-	-
14	Maintaining good relations with workers	-	-	-	-	-
15	Working with other members of the family	-	-	-	-	-
16	Exercising special abilities and aptitudes	-	-	-	-	-
17	Making maximum income	-	-	-	-	-
18	Providing congenial working conditions (hours, security, surroundings)	-	-	-	-	-
19	Meeting a challenge, achieving an objective, personal growth	-	-	-	-	-
20	Control in a variety of situations	-	-	-	-	-

8.6. Appendix VI: Uncertainty Survey (including Arrow of Attention)

Uncertainty in Farming

Uncertainty is a fact of life; it creates the business environment that provides us with both opportunities that can be captured and threats that must be overcome. It fills entrepreneurs with excitement and others with dread. For many it provides the buzz of business and is the reason why they chose being in business rather than in salaried employment. However, most research into this area deals only with the negative aspect of uncertainty, it has assumed the objective of all managers is to minimise risk (variation or uncertainty) rather than manage it. In many instances the cost of minimising risk is that you can also miss out on opportunities that can help your business grow. In this survey we ask you to tell us how you perceive certain risks, both from a positive and a negative perspective.

Opportunities over the next 5-10 years

Over a number of years, the business environment evolves as changes occur in our global markets, legislation, technology to name a few. Some of these changes create opportunities for your business. The potential to take advantage from these changes will differ according to the source of uncertainty and the scope you have to respond. For each long-term uncertainty, please circle a number that indicates: (1) What you believe is the potential for your business to benefit (1 = very low, 5 = very high) and (2) What you believe is the likelihood of this opportunity arising (1 = very unlikely, 5 = very likely)

	SOURCES OF UNCERTAINTY IN THE NEXT 5 to 10 YEARS	THE POTENTIAL TO BENEFIT FROM THIS UNCERTAINTY					THE LIKELIHOOD OF THIS POTENTIAL HAPPENING				
1	Climate variation	1	2	3	4	5	1	2	3	4	5
2	Operations & business practices	1	2	3	4	5	1	2	3	4	5
3	Pasture/crop/animal health	1	2	3	4	5	1	2	3	4	5
4	Interest rates	1	2	3	4	5	1	2	3	4	5
5	Credit availability	1	2	3	4	5	1	2	3	4	5
6	Land values	1	2	3	4	5	1	2	3	4	5
7	Global demand for farm products	1	2	3	4	5	1	2	3	4	5
8	Product and input prices	1	2	3	4	5	1	2	3	4	5
9	Competitors and competition	1	2	3	4	5	1	2	3	4	5
10	Supply chain to market	1	2	3	4	5	1	2	3	4	5
11	Business relationships	1	2	3	4	5	1	2	3	4	5
12	Technology (incl. breeding)	1	2	3	4	5	1	2	3	4	5
13	Customer relationships/image	1	2	3	4	5	1	2	3	4	5
14	Availability of labour (self and family, employees, contractors)	1	2	3	4	5	1	2	3	4	5
15	Skills and knowledge of those in or associated with the business	1	2	3	4	5	1	2	3	4	5
16	Government laws and policies	1	2	3	4	5	1	2	3	4	5
17	Local body laws and regulations	1	2	3	4	5	1	2	3	4	5
18	Other (please specify)	1	2	3	4	5	1	2	3	4	5

Threats over the next 5-10 Years

Over a number of years, the business environment evolves as changes occur in our global markets, legislation, technology to name a few. Some of these changes create threats to your business. The potential to be disadvantaged by these changes will differ according to the source of uncertainty and the scope you have to respond. For each long-term uncertainty, please circle a number that indicates: (1) What you believe is the potential for your business to be disadvantaged (1 = very low, 5 = very high) and (2) What you believe is the likelihood of this threat arising (1 = very unlikely, 5 = very likely).

	SOURCES OF UNCERTAINTY IN THE NEXT 5 to 10 YEARS	THE POTENTIAL TO LOSE FROM THIS UNCERTAINTY					THE LIKELIHOOD OF THIS THREAT HAPPENING				
1	Climate variation	1	2	3	4	5	1	2	3	4	5
2	Operations & business practices	1	2	3	4	5	1	2	3	4	5
3	Pasture/crop/animal health	1	2	3	4	5	1	2	3	4	5
4	Interest rates	1	2	3	4	5	1	2	3	4	5
5	Credit availability	1	2	3	4	5	1	2	3	4	5
6	Land values	1	2	3	4	5	1	2	3	4	5
7	Global demand for farm products	1	2	3	4	5	1	2	3	4	5
8	Product and input prices	1	2	3	4	5	1	2	3	4	5
9	Competitors and competition	1	2	3	4	5	1	2	3	4	5
10	Supply chain to market	1	2	3	4	5	1	2	3	4	5
11	Business relationships	1	2	3	4	5	1	2	3	4	5
12	Technology (incl. breeding)	1	2	3	4	5	1	2	3	4	5
13	Customer relationships/image	1	2	3	4	5	1	2	3	4	5
14	Availability of labour (self and family, employees, contractors)	1	2	3	4	5	1	2	3	4	5
15	Skills and knowledge of those in or associated with the business	1	2	3	4	5	1	2	3	4	5
16	Government laws and policies	1	2	3	4	5	1	2	3	4	5
17	Local body laws and regulations	1	2	3	4	5	1	2	3	4	5
18	Other (please specify)	1	2	3	4	5	1	2	3	4	5

Arrow of Attention Exercise

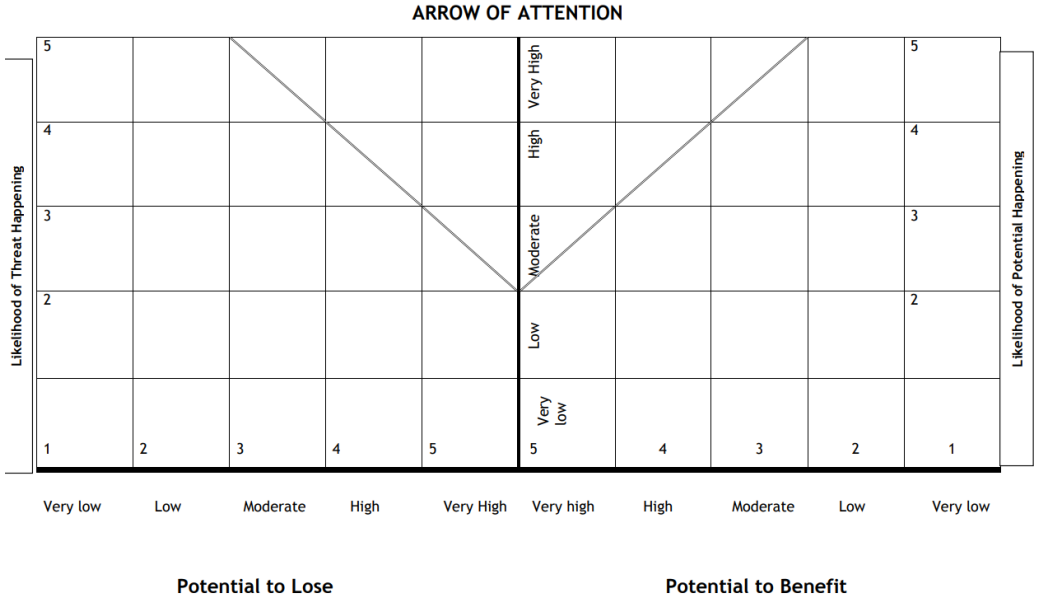

Figure 17 Arrow of Attention Exercise.

Potential to Benefit

From the first table take each uncertainty and plot the results into the right-hand side of the graph. For example, for climate variation put a number one (1) on the graph at the point that relates to the value you put on the potential to benefit (the right-hand horizontal axis) and your estimate of the likelihood of the potential happening (the vertical axis). As you may have more than one number at that point place your numbers in the square rather than on the intercept.

Potential to Lose

From the second table take each uncertainty and plot the results into the left-hand side of the graph. For example, for climate variation put a number one (1) on the graph at the point that relates to the value you put on the potential to lose (the left-hand horizontal axis) and your estimate of the likelihood of the threat happening (the vertical axis). N.B. the horizontal axis is the mirror image of that used for the potential to benefit values.

Arrow of Attention

Look closely at the uncertainties you have placed into the arrow of attention. You believe these uncertainties are likely to happen, some will benefit your business, others are a threat. Your business plan should, at the very least, address these uncertainties.

Black Swans

Look also at the 'black swans', the uncertainties that you have identified as having a very high impact on your business (either negative or positive) but that you believe are highly unlikely to happen. You will find them under the tip of the arrow. How well is your business prepared for these uncertainties if they should happen? Are there contingencies you need to have in place?

8.7. Appendix VII: Checklist of key topic areas for case farmer interviews

- Values and Goals (including personal and farm business)
  - Vision and Mission of the farm business
  - The main values and goals of the farm business and personal
  - What motivates them to have a profitable and productive farm business
  - Important aspects of the farm business strategy
- Adaptation Process (All Stages)
  - Scanning the environment for cues of change in relation to climate change
    - Monitoring of important elements in the environment
    - Information sources the farmer utilises to seek information
    - The role that their social networks play in the process
  - Identifying a change in the operating environment
    - How they determine if the climate is changing (perception)
    - How they determine what climate change will do to the local climate the farm operates within
    - How they determine what impacts the change will have on their farm system
  - Assessing the impact and nature of a change on their farm system
    - Assessing the impacts associated with climate change (including other change), what will these impacts mean for their farm system in terms opportunities or threats.
    - What is the extent and nature of this change on the farm system? (e.g., does it require the farmer to consider new strategy?)
  - Formulation of a suite of strategies to adapt to change
    - Internal farm analysis including identifying strengths and weaknesses of the farm business and assessing the on-farm resources (e.g., biophysical, human and financial)
    - Evaluating the current farm situation including the current strategy to cope with climate variation and the underlying conditions in the environment.
    - The decision to introduce change strategies or the decision to maintain existing strategies.
    - If a new strategy or strategies was required, what was the strategic thinking process that was used to formulate that strategy or suite of strategies, where are the strategic ideas derived from and what was the strategic planning process used to assess and plan the strategy or strategies
  - Implementing strategy to adapt to change
    - The strategic planning process continued - How was the strategy implemented, including the use of functional tactics and operational plans to aid strategy implementation.
    - The organisation of on-farm resources to support implementation
  - Monitoring and evaluating of the implemented strategy to enhance learning and build capacity
    - Control mechanism - How the farmer monitors the performance of the strategy and the how they evaluate its performance with planned or expected targets
    - How deviations are managed from the strategic plan (e.g., contingency plans)
    - How the farmer validates knowledge and information to improve their overall management capabilities

8.8. Appendix VIII: Results from the Values Exercise

Table 5 Values Exercise completed by the case farmer.

	Values	**Level of Importance**				
		1	**2**	**3**	**4**	**5**
1	Expanding the business			X		
2	Gaining recognition, prestige as a farmer		X			
3	Feeling pride of ownership				X	
4	Purposeful activity, value in hard work				X	
5	Enjoyment of work tasks				X	
6	Belonging to the farming community			X		
7	Making satisfactory income				X	
8	Continuing the family tradition		X			
9	Preference for a healthy, outdoor, farming life			X		
10	Gaining self-respect for doing a worthwhile job		X			
11	Chance to be creative and original		X			
12	Safeguarding income for the future				X	
13	Independence, freedom from supervision and to organise time				X	
14	Maintaining good relations with workers				X	
15	Working with other members of the family		X			
16	Exercising special abilities and aptitudes		X			
17	Making maximum income			X		
18	Providing congenial working conditions (hours, security, surroundings)				X	
19	Meeting a challenge, achieving an objective, personal growth				X	
20	Control in a variety of situations				X	

8.9. Appendix IX: Results from the Uncertainty Survey

Table 6 Uncertainty Survey (Opportunities over the next 5-10 years) completed by the case farmer.

	SOURCES OF UNCERTAINTY IN THE NEXT 5 to 10 YEARS	THE POTENTIAL TO BENEFIT FROM THIS UNCERTAINTY					THE LIKELIHOOD OF THIS POTENTIAL HAPPENING				
1	Climate variation	1	2	3	4	5	1	2	3	4	5
2	Operations & business practices	1	2	3	4	5	1	2	3	4	5
3	Pasture/crop/animal health	1	2	3	4	5	1	2	3	4	5
4	Interest rates	1	2	3	4	5	1	2	3	4	5
5	Credit availability	1	2	3	4	5	1	2	3	4	5
6	Land values	1	2	3	4	5	1	2	3	4	5
7	Global demand for farm products	1	2	3	4	5	1	2	3	4	5
8	Product and input prices	1	2	3	4	5	1	2	3	4	5
9	Competitors and competition	1	2	3	4	5	1	2	3	4	5
10	Supply chain to market	1	2	3	4	5	1	2	3	4	5
11	Business relationships	1	2	3	4	5	1	2	3	4	5
12	Technology (incl. breeding)	1	2	3	4	5	1	2	3	4	5
13	Customer relationships/image	1	2	3	4	5	1	2	3	4	5
14	Availability of labour (self and family, employees, contractors)	1	2	3	4	5	1	2	3	4	5
15	Skills and knowledge of those in or associated with the business	1	2	3	4	5	1	2	3	4	5
16	Government laws and policies	1	2	3	4	5	1	2	3	4	5
17	Local body laws and regulations	1	2	3	4	5	1	2	3	4	5

Table 7 Uncertainty Survey (Threats over the next 5-10 years) completed by the case farmer.

	SOURCES OF UNCERTAINTY IN THE NEXT 5 to 10 YEARS	THE POTENTIAL TO LOSE FROM THIS UNCERTAINTY					THE LIKELIHOOD OF THIS THREAT HAPPENING				
1	Climate variation	1	2	3	**4**	5	1	2	3	**4**	5
2	Operations & business practices	1	**2**	3	4	5	1	2	**3**	4	5
3	Pasture/crop/animal health	1	2	**3**	4	5	1	2	**3**	4	5
4	Interest rates	1	2	**3**	4	5	1	2	3	**4**	5
5	Credit availability	**1**	2	3	4	5	1	2	**3**	4	5
6	Land values	1	2	**3**	4	5	1	2	3	**4**	5
7	Global demand for farm products	1	**2**	3	4	5	1	2	3	**4**	5
8	Product and input prices	1	2	3	**4**	5	1	2	3	**4**	5
9	Competitors and competition	1	**2**	3	4	5	1	**2**	3	4	5
10	Supply chain to market	1	2	3	**4**	5	1	2	3	**4**	5
11	Business relationships	1	**2**	3	4	5	1	**2**	3	4	5
12	Technology (incl. breeding)	1	**2**	3	4	5	1	2	3	**4**	5
13	Customer relationships/image	1	2	**3**	4	5	1	2	**3**	4	5
14	Availability of labour (self and family, employees, contractors)	1	**2**	3	4	5	1	2	3	**4**	5
15	Skills and knowledge of those in or associated with the business	1	2	**3**	4	5	1	**2**	3	4	5
16	Government laws and policies	1	2	3	**4**	5	1	2	3	**4**	5
17	Local body laws and regulations	1	2	3	**4**	5	1	2	3	**4**	5