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Perceived adaptive capacity of New Zealand dairy farmers in the face of policy and economic volatility

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Abstract

Increasing global demand for dairy products provided the New Zealand dairy sector with the opportunity to expand. However, that expansion has come at a cost, with dairy farms becoming more reliant on external feed sources, increased debt financing, and irrigation water. At the same time, they have been exposed to a turbulent global economic environment and the increasing domestic concern over the environmental impact of dairying. Consequently, dairy farmers must balance economic efficiency and environmental sustainability in the face of increasing government regulation particularly around addressing deteriorating water quality. This requires dairy farmers and their farm businesses to be resilient, demonstrating some level of buffer capacity, adaptive capacity, and/or transformability. In a changing environment, adaptive capacity is key because a system's existing buffer capacity is unlikely to cope with such changes. In addition, it is important to avoid inadvertent transformation.

Due to the nature of adaptive capacity, the difficulty lies in attempting to measure it. To address this challenge and regarding the role of the decision-maker around adaptive capacity, a shift has begun to measure perceived adaptive capacity. For this measurement, a conceptual framework is required. A combination of five capitals and a decision-making framework was chosen. This conceptual framework is considered natural, physical, financial, human, and social capital. In addition, the risk or uncertainty confronting the business and the management practices are considered in the determination of dimensions for perceived adaptive capacity.

In this research, a sequential mixed method was selected. Four in-depth case studies were conducted via face-to-face interviews, focusing on the dimensions of the defined conceptual framework for perceived adaptive capacity. These interviews helped the researcher understand the New Zealand dairy farming context. In addition, the findings from the qualitative phase, alongside previous studies in New Zealand, informed the survey, disseminated to a larger sample of dairy farmers nationwide. The response rate for the survey was 51% (106 out of 209 emails sent) with usable data for analysis of 31% (65 farmers). Principal Component Analysis and Equal Weighting were utilised to calculate the score for seven dimensions for each farmer. The Analytical Hierarchy Process helped to

identify the relative importance of each dimension within the framework for each farmer. Finally, the farmer's perceptions of these dimensions and the relative importance of dimensions were used to develop an index of perceived adaptive capacity.

Introducing a new framework and developing an index for perceived adaptive capacity was novel to the literature. The framework provides a lens through the various dimensions that can be used to design a tool to assess perceived adaptive capacity. Moreover, the developed index for each farmer demonstrates that farmers have unique perceptions that build their index. Therefore, classifying farmers as adaptive or less adaptive cannot be conclusive. Instead, the relative importance of different dimensions illustrates whether the individual farmer perceives a dimension as more important than any other to them. A major step toward understanding and increasing the farmer's adaptive capacity starts from investigating their perceptions. It includes how they see the uncertainty in the environment, how they perceive their farming systems' capitals, and how important they see the management practices to cope with ongoing changes. The index of the perceived adaptive capacity, also, assists industry agents or advisors to see the farmer's self-assessment of their capacity to adapt to ongoing changes. In addition, the farmer's performance in a chosen timeframe shows the consistency (or lack of) between their perceptions and actions. A gap between perceptions and actions can result in a lack of adaptive capacity and may ultimately lead to an inadvertent transformation for the business.

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Abbreviations

Abbreviation	Explanation
SES	Social- Ecological System
OAD	Once- A- Day Milking
TAD	Twice-A-Day Milking
DM	Dry Matter
MS	Milk Solid
PKE	Palm Kernel Expeller
BW	Breeding Worth
PW	Production Worth
PCA	Principal Component Analysis
EW	Equal Weighting
AHP	Analytical Hierarchy Process
PACI	Perceived Adaptive Capacity Index

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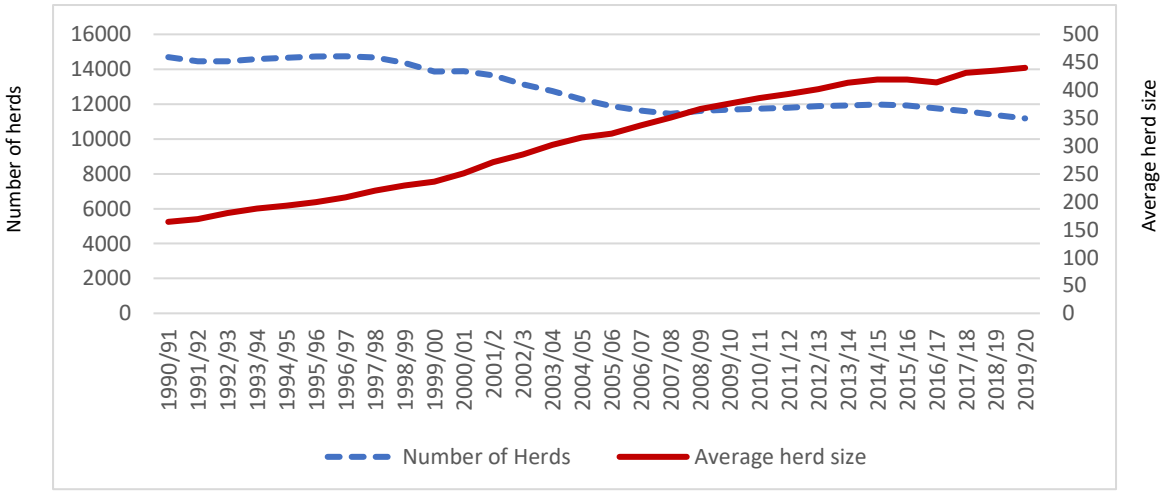
Chapter 1 : Introduction

1.1 The dairy industry in New Zealand

By virtue of New Zealand's natural environment, agriculture is the backbone of the economy with dairy and dairy-based industries dominant (Baskaran et al., 2009; Scrimgeour, 2020). The dairy industry has experienced significant growth in the past three decades in response to the increasing demand for dairy products in global markets (Baskaran et al., 2009; Foote et al., 2015). Evidence of this growth is in the annual dairy export values that rose from $4.0 billion to $20.1 billion between 1999 and 2020; contributing 17.08% of total export receipts for the year ending June 2019 (Mackle, 2019; MPI, 2021; Stats NZ, 2019). With respect to this growth, the dairy sector is the largest single contributor to New Zealand's total exports (Stats NZ, 2019). To achieve this growth the total effective area involved in dairy production has increased from 1,292,566 ha to 1,730,374 ha and the average farm's effective hectares increased from 93 ha to 155 ha between 1999 and 2020 (DairyNZ, 2020b). In addition, the average herd size has almost tripled in the last 30 years, from 164 to 440 cows while the number of herds or farms has declined from 14,685 to 11,179 herds (DairyNZ, 2020b). These trends are shown in Figure 1.1.

Figure 1.1: Trend in the number of herds and of the average herd size for the last 30 seasons



Source: Adapted from DairyNZ (2020b)

The expansion of the New Zealand dairy industry has also come at a cost. The impact on the environment in terms of deteriorating ground and surface water quality and the increased

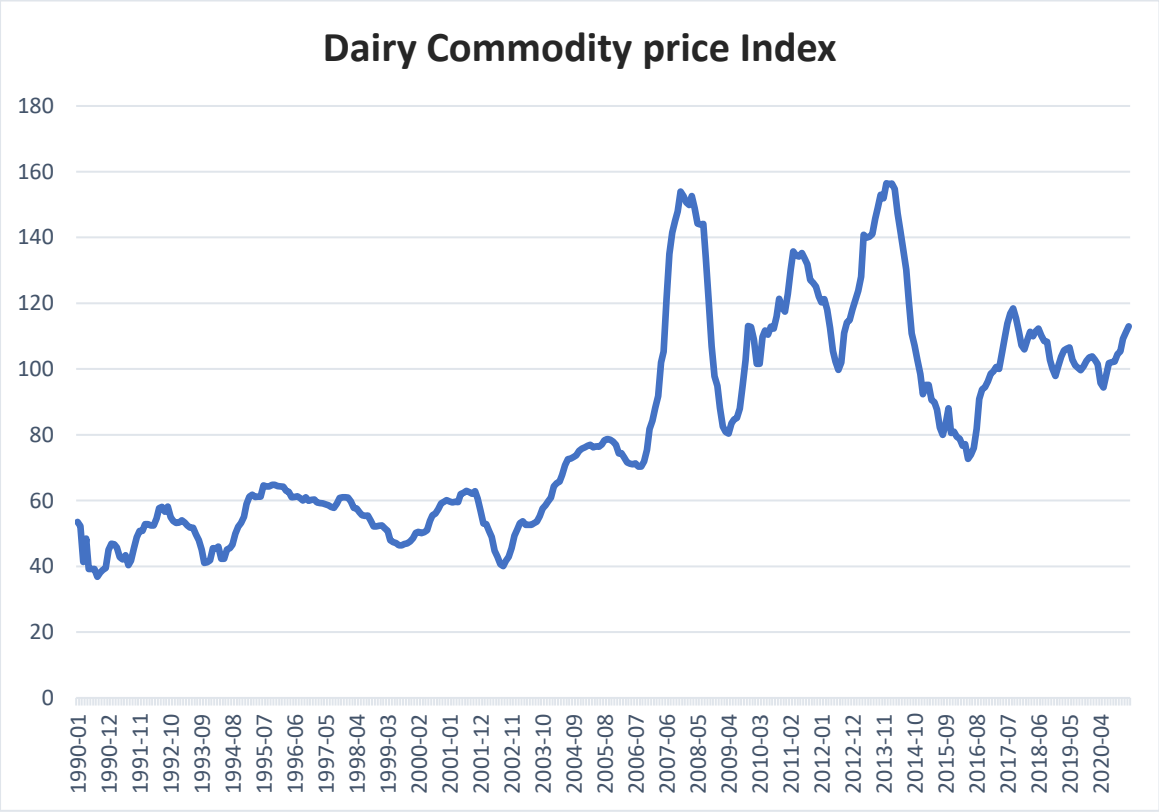
contribution to New Zealand's greenhouse gas (GHG) emissions will require changes for dairy farming in the future (Foote et al., 2015; Romera et al., 2020). Coupled with this is the added pressure of facing a more volatile global dairy market that impacts a dairy farm's milk payout, likely changes in regulation related to the environment, and other sources of uncertainty such as climate change impacts and interest rate volatility. These issues put dairy farmers and their farming systems under pressure. Resilience and adaptive capacity will be needed for a sustainable production pathway to be possible.

1.2 The dairy farming business environment in New Zealand

Over the past three decades, NZ dairy production has moved away from smaller family-owned farms to larger commercial farming enterprises, some of which are corporately owned (Townshend, 2016). The stocking rate (average cows per hectare) has increased from 2.30 cows/ha in 1990 to 2.84 cows/ha in 2020 and the number of cows milked in New Zealand increased from 2.40 to 4.92 million over the same period (DairyNZ, 2020b). An increase in global dairy prices after 2000 has led to the expansion and intensification of the dairy industry. The result was a conversion of sheep and beef farms to dairy, the introduction of irrigation in low rainfall areas and areas with drier summers, greater use of inputs such as nitrogen-based fertiliser, palm kernel (PKE), maize silage, grazing cows and replacements off the farm, and buying in feed (Forney & Stock, 2014; Ma et al., 2018). In addition, cost structures have changed significantly, due to a gradual increase in wages, feed supplementation, and land price adjusted for inflation (Pow et al., 2014). Consequently, throughout the period of change, many dairy farmers have borrowed heavily from banks to purchase increasingly expensive land, additional infrastructure (e.g. buildings and machinery), livestock, and other assets (Ma et al., 2020). At the same time, labour and feed costs have increased significantly (Ma et al., 2018). According to Pow et al. (2014), debt levels in 2014 were twice the level they were a decade earlier. Therefore, there is a very high debt level on New Zealand's dairy farms reported by the Reserve Bank of New Zealand (Greig et al., 2019). Dairy debt was NZ$40.75 billion (equivalent to approximately US$26.17 billion) in November 2019, which is 64.50% of agricultural debts and 6.27% of the country's total debts (Ma et al., 2020). In addition, the debt to asset ratio has been increased for owner-operators from 40.0% to 53.4% and for 50-50 sharemilkers from 44.3% to 61.6% during 2010-2019.

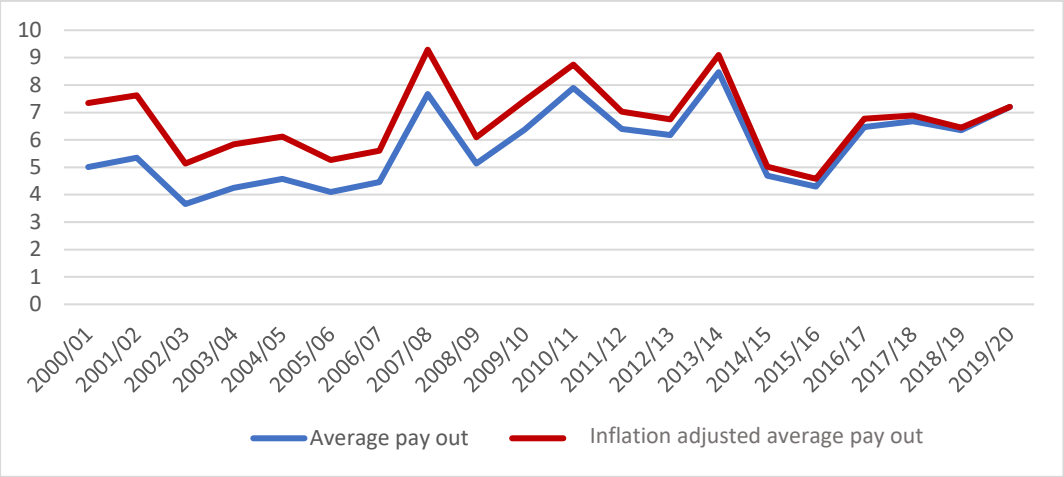
At the same time, dairy farmers have experienced greater milk price fluctuations, certainly in the last 20 years (DairyNZ, 2020b), as a consequence of being exposed to global markets (Shadbolt et al., 2013). The degree of change in the global dairy market is illustrated for the dairy commodities price over the last 30 years in Figure 1.2. The dairy commodities prices were relatively stable over the period 1990-2000, but since then they have increased and become increasingly volatile. Aligned with this increasing volatility in dairy commodity prices, the variation in milk price after the 2000 season, shown in Figure 1.3, shows how the dairy business environment is turbulent for New Zealand as the world's biggest dairy exporter. The most recent milk price fluctuation, coupled with dairy farmers' high level of debt financing has put pressure on the dairy sector that causes an ever-changing business environment for New Zealand dairy farmers (Shadbolt & Olubode-Awosola, 2016).

Figure 1.2: Dairy commodity price index (commodities include butter, whole milk powder, skim milk powder, cheese, and casein).



Source: FAO (2021)

Figure 1.3: Trend in prices received for milk solids for the last 20 seasons



Source: DairyNZ (2020b)

On one hand, the turbulent environment is a consequence of being exposed to the global market. On the other hand, the New Zealand dairy industry has flourished because of the increasing demand for dairy products in global markets. The response of the dairy sector has been to expand. The intensification of dairying in traditional dairy areas (like Taranaki and Waikato) has increased the need for external inputs to feed the increased number of animals being farmed (Foote et al., 2015). In areas not traditionally used for dairy farming (like Canterbury) investment in irrigation has required the use of underground aquifer water, or river take that is fed by snowmelt (Duncan, 2016; Foote et al., 2015). As a result, pastoral agriculture has become the largest consumptive use of water in New Zealand with a potential risk of microbial contaminants leaching into groundwater (Weaver et al., 2016). Thus, changes in land use from sheep and cattle farming to more intensive dairy farming have caused noticeable deterioration in the water quality of New Zealand's low-lying streams, rivers, and lakes (Howard-Williams et al., 2010). As a result, water management and allocation have been contentious in New Zealand, especially in the South Island, associated with water management issues for the farmers (e.g water consent applications) where access to water is being limited (Duncan, 2016). In many studies, it has been discussed that increased cow numbers and extensive use of fertiliser and irrigation are putting significant pressure on the environment (Blackett & Le Heron, 2016; Foote et al., 2015; Jay, 2007; Pow et al., 2014). In addition, the dairy sector contributes to the country's greenhouse gas (GHG) emissions, this comes primarily from the methane produced by the

cows, a by-product of rumen fermentation (Foote et al., 2015; Laubach et al., 2015). Livestock and urea application contribute to 37.3% of total GHG emissions in New Zealand[1]. As 95% of NZ milk produced is exported overseas as dairy products, from a global perspective, it can be an issue for New Zealand's clean green image (Blackett & Le Heron, 2016; Foote et al., 2015; Laubach et al., 2015). Subsequently, reducing the environmental footprint of dairy farming is an important priority in New Zealand (Bailey & Perrier, 2017).

To respond to the increasing concern about the environment, the dairy industry has tried using voluntary agreements (e.g. a Clean Stream Accord in 2002) (Jay, 2007). However, voluntary agreements have not been enough to decrease environmental impacts from the dairy sector. For this reason, the government has begun to introduce policy statements and plans for the implementation of environmental objectives and targets for farmers (McWilliam & Balzarova, 2017). Therefore, addressing these environmental issues will put a significant cost on dairy farmers through regulatory demands.

External pressures will also need to be managed at the farm level (Bailey & Perrier, 2017). Thus, dairy farmers will have to reduce their environmental footprint whilst remaining economically efficient (Bailey & Perrier, 2017). Both trade and the protection of the environment are important for the New Zealand economy (Cassells & Meister, 2001). In this vein, the dairy industry faces a volatile global market associated with milk price volatility and changing preferences of consumers from other countries. This is accruing at the same time as booming environmental changes within New Zealand which makes broader uncertain business conditions for the farmers. Therefore, the challenge for New Zealand dairy farmers is to balance economic efficiency in the face of fluctuating global dairy prices. Moreover, dairy farmers have internal disturbances such as staff loss, weed issues, and livestock diseases within their farm business to manage. To manage both internal and external pressures require a resilient farm business with an appropriate adaptive capacity.

1.3 The resilience of a farming system

Resilience theory addresses the capacity of systems to cope with and adapt to changes (Gunderson & Holling, 2002). Resilience has been used in diverse disciplines and one of the

[1] New Zealand's Greenhouse Gas Inventory 1990-2019 | Ministry for the Environment

disciplines that have been investigated is the resilience of farming systems (Alexander, 2013). Moreover, in the literature, coping with change is possible in the context of three attributes of resilience; buffer capacity, adaptive capacity, and transformability (Folke, 2006; Walker et al., 2004). It is useful to conceptualise farm resilience regarding the attributes of resilience. The three attributes of resilience can be linked to different intensities of shock or change (Béné et al., 2016c). Thus, knowing the nature of changes also helps to understand the attributes of resilience.

Meuwissen et al. (2019) defined a resilient farming system as one that copes with disturbances and uncertainties. In another definition, Darnhofer (2014) stated that the common use of resilience of farming systems focuses on the ability to respond effectively to change, especially unpredictable and sudden changes. In addition, the resilience of farming systems is studying how farm businesses cope with different external and internal changes (Anderson & McLachlan, 2012; Bouttes et al., 2019; Kenny, 2011). Thus, a resilient farm business is able to absorb threats caused by disturbances while reorganising and adapting to changes and developing system functions (Darnhofer, 2014). Disturbances such as those caused by market volatility, climatic fluctuations, and environmental constraints are commonly faced by farmers in more recent times that require three attributes of resilience to be covered (Béné et al., 2016c; Darnhofer, 2014).

Buffer capacity is the ability of a system to absorb a disturbance and reorganise to maintain the same function, structure, and identity (Darnhofer, 2014; Folke, 2006; Walker et al., 2004). Adaptive capacity is the ability of a system to adjust in the face of changing external drivers and internal processes, thereby allowing for the development of the system's function while maintaining the current identity (Folke et al., 2010; Walker et al., 2004). This development can be achieved by seizing opportunities that arise from disturbances (Folke, 2006). In addition, adaptive capacity is useful when the system needs development to take a deliberate transformation (D. R. Nelson et al., 2007). Transformability is the ability of a system to create a fundamentally new system (with a different function, structure, and identity) when its current conditions such as ecological, economic, or social conditions are no more tenable (Walker et al., 2004). The transformation of a system is initiated either because a manager is forced to change due to changing environmental conditions (an

inadvertent transformation) or it can be deliberately initiated by the manager of a system (a deliberate transformation) (Folke et al., 2010; D. R. Nelson et al., 2007).

Adaptive capacity is two-sided assistance that plays an important role when it is required to prepare the system to respond and adjust itself to a major shift in the business environment (Béné et al., 2014; D. R. Nelson et al., 2007). In an ever-changing environment, sometimes the degree of change is beyond the bounds of buffer capacity so that the system cannot simply maintain the same function, structure, and identity (Folke et al., 2010; D. R. Nelson et al., 2007). Hence, the system needs the ability to adjust in the face of changes allowing for the development of the system's function either maintaining the current identity or the ability to take advantage of changes to prepare for a fundamentally new system, namely deliberate transformation (D. R. Nelson et al., 2007).

According to the literature, the resilience of a farming system is understood as covering the three above-mentioned attributes facing different disturbances (Béné et al., 2012; Darnhofer, 2014; Davoudi et al., 2013). For example, in terms of buffer capacity, it may be how a farming system can weather a shock such as a sudden price increase, or a short drought without substantial changes on the farming system. In terms of adaptive capacity, it may be how a manager of a farming system can identify problems, establish priorities, and combine experience with knowledge to adjust to the changing context such as new marketing channels, or new regulations. In terms of transformability, this is where the farming system adopts new basic operating assumptions such as transforming a cattle farm on rangeland into an ecotourism operation (Darnhofer, 2014). When the change is not big enough to transformation happen for a farming system, adaptive capacity is crucial to find pathways to moderate the consequence of change and exploit beneficial opportunities when a disturbance happens (Birkmann et al., 2010; Jacobs et al., 2015). Nevertheless, assessing or measuring adaptive capacity needs to have an understanding of the concept and characterising adaptive capacity in a suitable framework (Engle, 2011).

1.4 Adaptive capacity for dairy farming in New Zealand

In terms of assessing or measuring adaptive capacity, there have been some approaches in the climate literature with an emphasis on the vulnerability concept (Choden et al., 2020; Engle, 2011). However, the approaches, also, are applicable to adaptive capacity as an

attribute of resilience because adaptive capacity is a linkage between vulnerability and resilience (Engle, 2011; D. R. Nelson et al., 2007; Vogel et al., 2007). Since adaptive capacity has a latent nature, it should be considered within a system (Choden et al., 2020). To do this, defining a suitable framework as a basis for analysis is required to carry out adaptive capacity measurement in practice (Choden et al., 2020; Engle, 2011). Thus, firstly, defining a theoretical framework is required for measuring the dairy farming system's adaptive capacity. Then choosing a method for measurement within the framework, is required (Choden et al., 2020; Engle, 2011; R. Nelson et al., 2010). The combination of framework and the method provides insights into dairy farming systems' adaptive capacity.

1.5 Problem statement

Regarding adaptive capacity as an attribute of resilience in the New Zealand dairy farming context, the dairy farmers need to reduce their environmental footprint whilst remaining economically efficient. Therefore, it is assumed that it is the farmer's preference to stay in the dairy industry whilst adapting to a range of disturbances such as has been mentioned, which is consistent with the adaptive capacity for the farm business. The adaptive capacity of farming systems has been explored theoretically in the literature (Darnhofer, 2014; Darnhofer et al., 2008; Duranovich, 2015; Nettle et al., 2018; Thapa et al., 2016), however, its measurement has been less researched (Lockwood et al., 2015). Also, studies on adaptive capacity measurement have been mostly on community resilience focusing on the objective assessment of different assets, which have been expanded based on the sustainable livelihood framework (Huai, 2016; R. Nelson et al., 2010; Thapa et al., 2016). This framework is noticeable in studies of farming system's adaptability under the five-capitals framework, however, it does not fully conceptualise some capitals such as human and social properly, which are capitals that focus on individuals as decision-makers and play an important role in the farm business and farmer's adaptive capacity (Nettle et al., 2018). To focus on individuals, Duranovich (2015) considers New Zealand dairy farmers' resilience attributes that bring insight to human capital, however, it does not attempt to measure adaptive capacity. Since very few studies attempt to measure the adaptive capacity of farm businesses (Lockwood et al., 2015), there is a gap in the literature for conceptualising a framework for measuring a farming system's adaptive capacity.

Investigating the literature shows that a chosen framework for adaptive capacity needs to be a translation of disturbances, characteristics of the system, and the influence of human actions (Choden et al., 2020; Engle, 2011; R. Nelson et al., 2010; Vincent, 2007). In terms of disturbances, the business environment defines the type of disturbances that the dairy farmers are having to cope with, including sudden shocks and long-term stresses. A shock, like a fall in the global milk price, and long-term stress, like the requirement for compliance with likely increasing environmental regulations, help to describe the context of New Zealand dairy farming. Since each of these disturbances contributes to costs, whether social, financial, or time, and farm survival; therefore, they affect the adaptive capacity of the farming system. Disturbances in the dairy farming context contribute to the theoretical framework of adaptive capacity for dairy farming in New Zealand.

In terms of characteristics of the system and human action, the dairy farmer's ability to mitigate threats and adapt to opportunities offered by the changes can be considered using the capitals of the business as a dimension of a theoretical framework. Moreover, based on the literature, each farmer relies on the farm business's capital to manage different disturbances and to shape its adaptive capacity (Darnhofer, 2014). These capitals are natural, physical, financial, human, and social capital (Béné et al., 2016c; Ellis, 2000; R. Nelson et al., 2010). Management practices enabled by the capitals to cope with disturbances also contribute to the theoretical framework for adaptive capacity.

Furthermore, in a farming system, the farmers are the main decision-makers. The perception of decision-makers about their business demonstrates their understanding of the business's capacities to deal with disturbances (Nguyen & James, 2013). In the literature, looking for a decision-maker's perceived level of resilience has been introduced as a subjective assessment approach measurement (Jones & Tanner, 2015; Nguyen & James, 2013). This approach leads to the concept of "perceived adaptive capacity" in this research that needs a set of questions to be asked through different methods such as case studies or survey techniques to be measured (Jones & Tanner, 2015). Designing questions for a subjective assessment approach is very important. Asking designed questions helps to investigate the farmer's perceptions of disturbances, the appropriate capitals at the farm level, and the management practices to cope with changes.

First, considering the abovementioned dimensions of adaptive capacity for dairy farming in New Zealand with regard to conceptualising the concept of "perceived adaptive capacity" is a significant contribution of this study. Second, developing a measurement tool for perceived adaptive capacity is new to the body of literature.

1.6 Research aims and objectives

This research aims to develop a metric to assess and measure perceived adaptive capacity for dairy farmers in New Zealand. The perceived adaptive capacity measurement would make it possible to draw on the literature and understand the dimensions that influence a dairy farmer's perceived adaptive capacity.

The research questions that guided this research are as follows:

- What are the dimensions of the New Zealand dairy farmers' perceived adaptive capacity when facing external or internal pressures?
- Can an index be developed to measure a dairy farmer's perceived adaptive capacity?
- How do the dimensions affect the perceived adaptive capacity index?

The following objectives will be met to address the above questions:

- To design a conceptual framework to describe a New Zealand dairy farmer's perceived adaptive capacity when facing challenges due to disturbances.
- To investigate the dairy farmer's perception of disturbances; shocks and stresses in the context of a dairy farming business in New Zealand.
- To identify management practices affecting the utilisation of the capitals of a dairy farming business.
- To develop a measurement tool for New Zealand dairy farmers' perceived adaptive capacity.

This study contributes to the literature in two ways: conceptualising a framework to assess perceived adaptive capacity for dairy farming and developing a tool to measure the perceived adaptive capacity of dairy farmers in New Zealand.

Firstly, a qualitative phase provides the notion of farmers' perceptions in the New Zealand dairy farming context. This phase explores the disturbances that the farmers have

experienced or expect to experience, along with the farmers' responses to the disturbances utilising farm business's capitals. The findings from the qualitative phase are utilised to design a survey instrument for the quantitative phase. Secondly, through the quantitative phase, an index is developed to measure a dairy farmer's perceived adaptive capacity. This index would be helpful to identify those dimensions that could be improved to strengthen a dairy farmer's perceived adaptive capacity.

1.7 Thesis structure

This thesis is organised into seven chapters. Chapter One contains the background of the New Zealand dairy industry along with describing the research aims and questions. Chapter Two reviews the relevant literature on resilience concepts with an emphasis on adaptive capacity to develop a theoretical framework for conducting this study. The methods and data are described in Chapter Three. Chapters Four and Five report the qualitative and quantitative results of the study, respectively. Chapter Six provides the discussion and Chapter Seven concludes the thesis.

Chapter 2 : Literature review

2.1 Introduction

The concept of resilience emerged in the field of ecology almost four decades ago (Angeler & Allen, 2016). Since then, three key attributes of resilient systems have developed, namely, buffer, adaptive, and transformative capacities (Angeler et al., 2019; Walker et al., 2004). In addition, over time the resilience concept has been adopted by a range of disciplines including farm management (Bouttes et al., 2019; Jacobs et al., 2015; McDonald, 2017). It is in the discipline of farm management that this study is situated, with a focus on the measurement of New Zealand dairy farmers' perceived adaptive capacity. To do this, it is required to explore the resilience literature, the concept of adaptive capacity in farm management, and other concepts from different disciplines to find more about adaptive capacity measurement. The concepts from various disciplines assist to distinguish a framework for developing an index to measure perceived adaptive capacity. Thus, this study is an attempt to utilise a suitable framework to answer the following questions:

- What are the dimensions of the New Zealand dairy farmers' perceived adaptive capacity when facing external or internal pressures?
- Can an index be developed to measure a dairy farmer's perceived adaptive capacity?
- How do the dimensions affect the perceived adaptive capacity index?

In this chapter, the evolution of "resilience" in ecological and social-ecological systems was explored. Resilience for social-ecological systems can be described through three attributes: buffer capacity, adaptive capacity, and transformability. Moreover, the resilience attributes were expanded through a range of disciplines. Among these disciplines, the resilience of farming systems was explained followed by the nature of disturbances and the common disturbances for farming systems. The aim of this research was to explore adaptive capacity in the context of dairy farm management. Afterward, measuring resilience was explained via measurement instruments and two approaches of measurement: subjective and objective. Furthermore, exploration of the literature on measuring adaptive capacity assisted to identify a suitable framework to develop an index for the perceived adaptive capacity.

2.2 The evolution of the concept of resilience

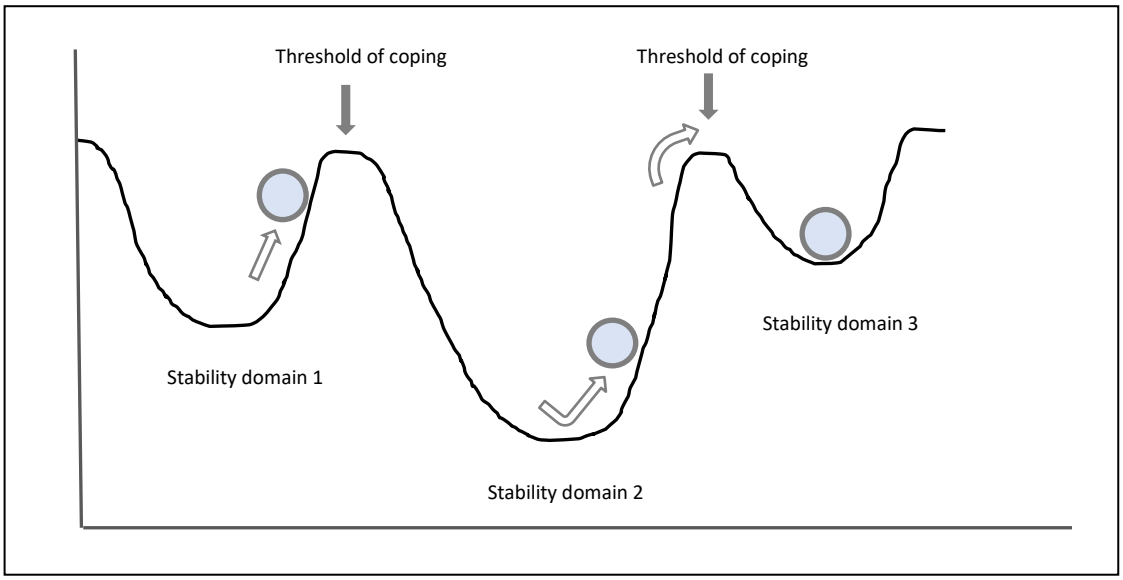
The word ‘resilience’ has a root in the Latin word ‘resilire’ meaning the idea of bouncing back, which means recovering or reacting (Alexander, 2013). Although it was firstly used in science in 1858, later it started to be a word in common for diverse disciplines with broader meanings and connotations (Alexander, 2013; Darnhofer, 2014). The focus of all meanings of resilience has been the ability to effectively respond to ongoing and unpredictable changes (Folke et al., 2010). This section reviews the development of the concept of resilience that started in ecology in 1973, and its integration into social-ecological systems and other disciplines such as organisations, livelihoods, and farms.

2.2.1 Resilience in ecological systems

The pervasive concept of resilience emerged from a seminal paper by Holling (1973) in ecology, who brought forth a new point of view about ecological systems’ behaviour. He argued that systems confronted by unexpected external changes show two kinds of behaviour: stability and resilience. Stability is defined as the time it takes a system to return to a previous equilibrium state, while resilience is a measure of a system’s persistence, which is its ability to absorb disturbances without changing the relationship between the system’s internal variables (Holling, 1973). Following on from this definition of resilience by Holling (1973), other scholars represented the concept of resilience as an ecological system’s ability to absorb changes and disturbances, while maintaining its core function over time (Ives, 1995; Mittelbach et al., 1995; Neubert and Caswell, 1997). In addition, Holling (1996) distinguished between two types of resilience: engineering and ecological. The time required for a system to return to equilibrium following a disturbance is engineering resilience or stability. However, the ecological resilience definition is a different concept, in which, there is more than one equilibrium for a system. Based on this premise, the magnitude of a disturbance that can be absorbed before the system shifts into another state of equilibrium is ecological resilience or the system's resistance to a disturbance (Gunderson & Holling, 2002). Ecological resilience, which does not emphasise a steady-state condition, considers the ‘unsteadiness’ of a system as a reason to switch to another regime

of behaviour for the system[2]. This regime switch is the assumption of multiple stable states for a given system (Gunderson, 2000). Some scholars provide a heuristic diagram of a ball and cup to highlight the differences between engineering and ecological resilience (Carpenter & Cottingham, 1997). Figure 2.1 shows this diagram, the ball indicates the system state, and the cup indicates the stability domain or stability regime. As Gunderson (2000, p.427) stated: "An equilibrium exists when the ball sits at the bottom of the cup and disturbances shake the marble to a transient position within the cup".

Figure 2.1: A ball and a cup heuristic diagram



Source: Adapted from Lamothe et al. (2019)

In the heuristic diagram, after any disturbance, the ball's path depends on the gradient of the sides of the basin and the width of the basin (Beisner et al., 2003; Lamothe et al., 2019). Characteristics of the shape of the cup dictate the return time of the ball to the bottom of the cup, which reflects engineering resilience (Holling, 1996). The magnitude of the disturbance affects the likelihood of moving the ball (system) outside the basin and a large push can cause the ball to move outside the boundaries of the basin. The magnitude of the disturbance required to move outside the boundaries is what Holling (1996) called ecological resilience. Ecological resilience refers to the width of the basin, which is called the stability domain and Holling (1996) proposed that more than one stability domain exists for

[2] Regime shift is sudden and long-lasting changes in structure and function of many ecological systems. These changes are often called critical transitions (Lade et al., 2013; Scheffer et al., 2009).

a system. When the ball crosses the system's threshold of coping (shown in Figure 2.1), it will switch to a new stability domain or alternate regime (Scheffer & Carpenter, 2003).

To manage the systems confronted by disturbance, these two resilience definitions can yield very different approaches (Holling, 1973, 1996). While engineering resilience suggests managing systems for stability, efficiency, and optimisation that work in the short run, ecological resilience has a long-run perspective to manage a system (Gunderson, 2000; Holling, 1996). In the long run, the application of engineering resilience alone for a system may reduce its ecological resilience, by not letting the system switch its behaviour and find a better stability domain during the time (Holling, 1973). Therefore, return time to equilibrium that is dependent on engineering resilience (Holling, 1996), cannot be an appropriate measure of resilience in the long term. Rather, the key measure of an ecological system's resilience is its persistence, which is measured by the amount of disturbance that can be absorbed before the system shifts into another stability domain (Gunderson, 2000).

In the early literature on resilience for ecological systems, the underlying assumption concerning resilience presents it as a static property of the system (Carpenter et al., 1999; Carpenter & Cottingham, 1997; Scheffer et al., 1993). Being a static property of the system means that the shape of the cup (shown in Figure 2.1) is fixed over time (Gunderson, 2000). Nonetheless, several studies have shown that the stability domain or the shape of the cup or cups (stability domains) in Figure 2.1 is dynamic and that the stability domains of ecological systems change at a relatively slow rate (Gunderson, 2000; Scheffer et al., 1993). This slow rate of ecological system change is observable when there is no human interaction; however, human activities cause confounding problems around ecological resilience (Connell & Sousa, 1983). Therefore, human beings play a significant role in influencing the variation of the key variables that affect the stability of an ecological system (Gunderson, 2000). The following section represents definitions of social-ecological systems' resilience, which considers human beings' role in the system's resilience.

2.2.2 Resilience in social-ecological systems

To study the interactions between human and ecological systems, Berkes & Folke (1998) developed the concept of 'social-ecological systems' (SESs). The SES concept is a description of the social and ecological linkages within a system, where humans are an integrated part

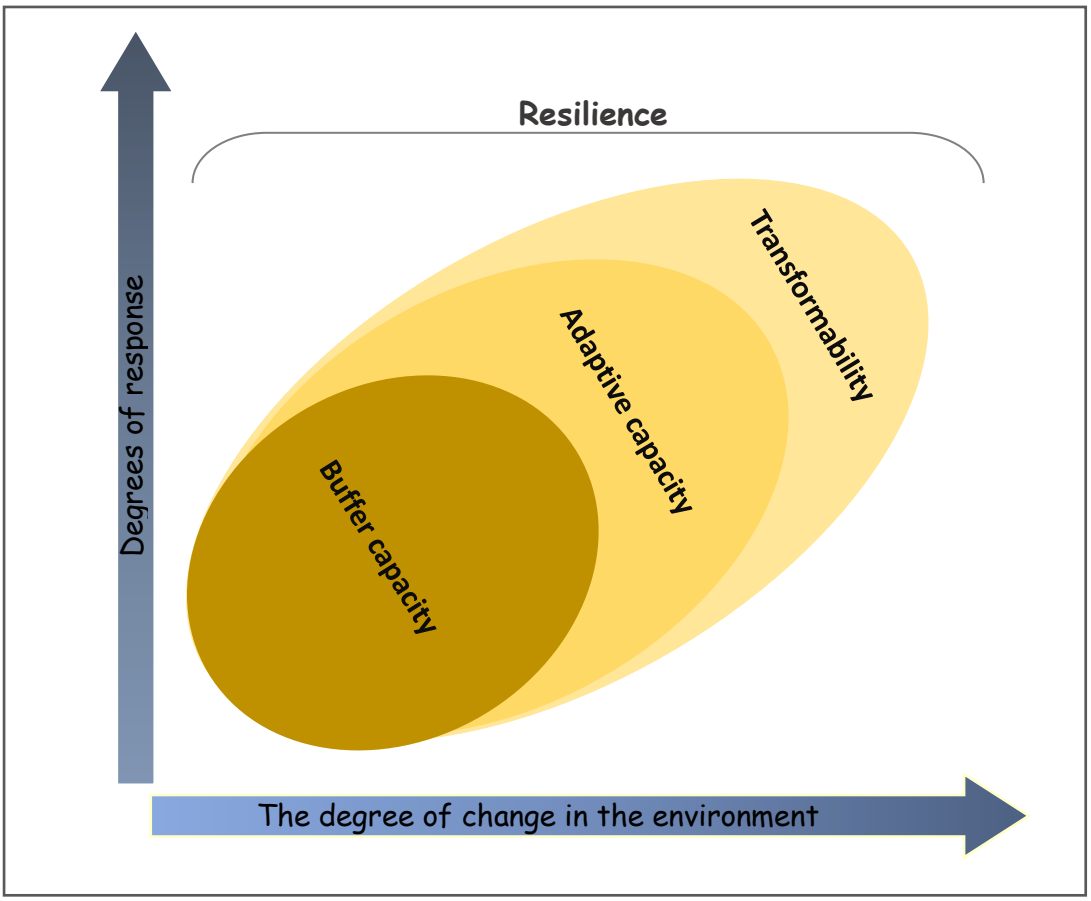
of nature (Colding & Barthel, 2019). In this vein, a resilient SES is different from a resilient ecological system (Folke, 2006). If resilience means being persistent to absorb disturbances for an ecological system, for an SES it can be translated to a potential to create new opportunities from disturbances, resulting in the system's innovation and development (Folke, 2006). This important role that is undertaken by the social subsystem of an SES is known as 'adaptability' or its 'adaptive capacity' (Folke, 2006; Walker et al., 2004). The adaptability of the actors in the system, or the capacity of system managers to adapt, influences its resilience (Folke, 2006; Walker et al., 2004). Based on this adaptation capability, a resilient SES can adapt, and transform when facing a shock or changing environment, which is more than persisting through the disturbances (Folke, 2006; Mitchell & Harris, 2012). Thus, the ability to adapt and transform is at the core of the resilience definition in SESs (Béné et al., 2014). These concepts highlight the multi-dimensional nature of resilience for SESs (Folke, 2006; Walker et al., 2004, 2006). Therefore, an SES's resilience is not only about absorbing changes but also includes the system's adaption and transformation abilities as well (Aldunce et al., 2015; Folke, 2006; Pelling, 2010). The attributes of SESs in the vein of resilience were introduced by Walker et al. (2004). These attributes are adjusted into buffer capacity, adaptive capacity, and transformability (Béné et al., 2014), which are discussed in the following section.

2.2.3 The attributes of resilient social-ecological systems

Walker et al. (2004) specified three attributes of a resilient SES; resilience, adaptability, and transformability. Under Walker et al.'s (2004, p.2) definition for the first attribute, "resilience is the capacity of a system to absorb disturbance and re-organise while undergoing change so as to still retain essentially the same function, structure, identity, and feedback". Complementary to this, Folke (2006) stated that the definition for the first attribute is consistent with resilience for ecological systems when it refers to the capacity of absorbing disturbances or buffer capacity that allows persistence. Therefore, Folke (2006) believed that the term 'buffer capacity' should be used for the first attribute instead of the term 'resilience' in Walker's definition. Since the meaning of resilience is much broader than buffer capacity, being resilient is not just being persistent when disturbances occur (Folke, 2006). In Folke's (2006) definition and later by Béné et al. (2012, 2014), resilience is an overarching term that covers buffer capacity, adaptability, and transformability altogether.

In other words, resilience results from the three core attributes; buffer capacity, adaptive capacity, and transformability of a system under consideration (Béné et al., 2012, 2014). Figure 2.2 illustrates the concept of resilience and the three core attributes of resilience for SESs.

Figure 2.2: The attributes of resilient social-ecological systems



Source: Adapted from Béné et al. (2016c)

Buffer capacity helps when the system is in a relatively stable environment, however, a rapidly changing environment requires the other attributes; adaptive capacity and transformability (Béné et al., 2016c). In the conceptualisation of the latter two capacities, the system's ability to learn, utilise previous experiences, and adjust its responses to a higher degree of changes were recognised to be at the core of resilience (Béné et al., 2014; Berkes et al., 2008). The three capacities are described below.

2.2.3.1 Buffer capacity

Buffer capacity is an attribute of SESs to absorb disturbances (Folke, 2006). This capacity is an ability of SES to conserve what the system has and recover to what it was, which demonstrates the capacity to absorb disturbances and persist (Folke, 2006; Folke et al., 2010). In the same way, Carpenter et al. (2001) defined buffer capacity as the amount of change a system can undergo and retain the same structure, function, identity, and feedback on function and structure. Therefore, buffer capacity is considered as the first attribute of a resilient SES, which helps a system to be persistent and to return to its previous function (Folke, 2006; Rose, 2009; Speranza, 2013). This capacity is a critical attribute of a resilient system since every resilient system requires this capacity to absorb perturbations before the system changes its structure (Carpenter et al., 2001; Gunderson & Holling, 1995; Walker et al., 2004). When the environment is changing slowly or is relatively stable, buffer capacity characterises a system's built-in unused capacity to anticipate gradual changes and to absorb potential shocks (Francis & Bekera, 2014). However, it is not adequate for renewal, re-organisation, and development (Folke, 2006). Buffer capacity does not satisfy the higher intensity of changes (Béné et al., 2016c). Therefore, an SES needs the other two attributes; adaptive capacity and transformability depending on the degree of change to respond to frequent and higher changes in the environment (Béné et al., 2016c; Folke, 2006; Walker et al., 2004). The frequent and rapid pace of changes requires SESs to accept changes as a part of their life cycle and to keep the system adaptive to respond to new challenges as they arise (Carpenter & Gunderson, 2001; Darnhofer et al., 2010a). However, the higher degree of change in the environment can cause an ultimate change in the function of the SES which is called transformation (Béné et al., 2014; D. R. Nelson et al., 2007). When recognising that the environment, including ecological, social, and economical, has changed and a system does need to make some changes, the adaptation is the important attribute of resilience (D. R. Nelson et al., 2007). Regarding the fact that the change is not that much for the transformation, the existing system needs to be adapted (Béné et al., 2016c).

2.2.3.2 Adaptive capacity

The general ability to persist in the face of disturbance is a necessity for a resilient SES, however, the concept of resilience about SESs additionally incorporates the idea of

adaptation, learning, and self-organisation (Folke, 2006; Walker et al., 2004). A system's ability to adjust to new situations resulting from frequent changes or the rapid pace of changes is known as its adaptive capacity (Fiksel, 2006; Francis & Bekera, 2014; Smit & Wandel, 2006; Walker et al., 2004). This capability emerges out of the system's self-organisational ability (Folke et al., 2005). Where self-organising capacity is crucial for the dynamics of SESs facing disturbance due to renewal, re-organisation, and development (Folke, 2006; Smit & Wandel, 2006). In this vein, according to Walker et al. (2004), human action dominates SESs. Also, the learning ability of humans involved in a SES plays a key role in making the system's adaptive capacity to manage changes (Béné et al., 2014). For adaptable SESs, the actors within SESs are prepared for uncertainties and disturbances, not as unexpected events, but rather as events that they should learn to live with (Carpenter & Gunderson, 2001). Being prepared for uncertainties makes it possible to identify disturbances as either threats or opportunities (Folke et al., 2005; Shadbolt et al., 2013). Highlighting the role of actors within SESs, disturbances can be considered as a window of opportunity to navigate social-ecological transition by recombining knowledge and experiences (Béné et al., 2014; Folke et al., 2010). Moreover, humans having the capacity of anticipation and intentional action (Gunderson & Holling, 2002), makes the adaptive capacity of SESs a function of the individuals and groups managing the respective systems (Williamson et al., 2012).

The ability to anticipate and recognise disturbances along with re-organising after disturbances demonstrates a system's adaptive capacity (Francis & Bekera, 2014). This capacity provides the ability for deliberate useful and developmental changes within the system when required (Folke et al., 2010; D. R. Nelson et al., 2007). Adaptive capacity results in resilience SES (Gunderson, 2000; Walker et al., 2004). However, when the disturbances make the current system untenable, the system needs to be transformed. In this vein, being prepared for a deliberate transformation (not a collapse) highlights the importance of the adaptive capacity of SESs (D. R. Nelson et al., 2007). Adaptive capacity, on one hand, is suitable to prepare an SES to respond and adjust itself to a major shift in the environment (Béné et al., 2014; D. R. Nelson et al., 2007). On the other hand, it is suitable for a certain degree of environmental change to which the buffer capacity is not able to respond (Folke et al., 2010; D. R. Nelson et al., 2007). Therefore, adaptive capacity involves

changes either from the viewpoint of enhancing resilience to buffer undesirable external changes or from the viewpoint of taking advantage of changes (D. R. Nelson et al., 2007). In other words, adaptive capacity includes finding the pathways to moderate the consequence of change and exploiting beneficial opportunities when a disturbance happens to a SES (Birkmann et al., 2010; Jacobs et al., 2015).

2.2.3.3 Transformability

Walker et al. (2004) described transformability as one of the resilient SES's attributes. Transformation occurs when the existing system is not more tenable in the current ecological, economic, and/or social conditions; hence, a fundamentally new system has to be created (Walker et al., 2004). Facing an untenable situation is the time when the changes overwhelmed the adaptive capacity of an SES, consequently, the system needs to experience an ultimate level of change in its function (Béné et al., 2014; D. R. Nelson et al., 2007). This ultimate change is the transformation that defines the system's transformability attribute (Folke et al., 2010; Shadbolt et al., 2013). Transformability is different from the buffer and adaptive capacity since the degree of change in the environment forces the SES to a fundamental change (Béné et al., 2014; Béné et al 2016c; D. R. Nelson et al., 2007). There are two types of transformation; one type is the inadvertent transformation or collapse, in which the transformational change can happen inadvertently due to changing environmental or socioeconomic conditions (D. R. Nelson et al., 2007). The other type is the deliberate transformation, which is undertaken as a deliberate change by the people involved to avoid the consequences of collapse (Folke et al., 2010; D. R. Nelson et al., 2007). Regarding the second type, D. R. Nelson et al. (2007) argued that a desirable transformation results from an appropriate adaptation process, whereas an inadvertent transformation results from a system having insufficient ability to resist and adapt. Consequently, a system with high adaptive capacity can be well-prepared for system adjustment and deliberate transformation while avoiding collapse (Béné et al., 2016c; D. R. Nelson et al., 2007).

The concept of resilience has been expanded through a range of disciplines. The exploration of resilience across disciplines assists answer the research questions and finding a proper framework for this study.

2.3 Resilience across disciplines

The concept of resilience has been expanded to other research disciplines. In psychology, a simple definition of resilience is individuals' positive adaptation in response to adversity, either changing life circumstances or experiencing trauma (Waller, 2001). In organisational management, resilience includes the ability of a business to effectively absorb and respond to the changes that arise in the environment (McCann, 2004). At the community level, resilience is an essential part of public health policies and programs (Brown & Kulig, 1996), thus a resilient community can respond to unexpected shocks such as natural hazards (Bhandari, 2013; McManus et al., 2012; Riolli & Savicki, 2003). Resilience in the farm management literature has been introduced to address the issue of farming systems and farm businesses to effectively cope with disturbances and changes in the environment (Crawford et al., 2007b; Darnhofer, 2014; Kaine & Tozer, 2005; Shadbolt et al., 2011). This study is situated in the discipline of farm management with a focus on the adaptive capacity of New Zealand dairy farmers. Thus, after exploring the resilience literature, it is required to investigate the resilience of farming systems, resilience attributes for farm management in general, and the adaptive capacity in particular for farming systems.

2.3.1 The resilience of farming systems

Defining farming systems helps to understand the context of the dynamics of a farming unit (Darnhofer et al., 2012) in which farmers allocate the resources for farming (Norman, 2002). A farm is a purposeful system composed of various capital components to produce food, fiber, or other agricultural products (Conway, 1987; Dillon, 1992). In a system named a farm, the farm's components work together as an open system interacting with the physical, social, economical, and political environment, where the characteristics of the farm change over time in response to internal or external influences (Cowan et al., 2013; Dillon, 1992; McConnell & Dillon, 1997). Thus, it can be stated that a farming system is a structure consisting of a set of components such as soil, livestock, and physical structures managed by individuals and their social values to reach a set of goals (Conway, 1987, 1993; Goulden et al., 2013). Moreover, the interaction between socio-economic and ecological processes makes farming systems or agroecosystems complicated (Conway, 1987). The complex structure of a farming system arises from its social and ecological dynamics, which introduce

it as an SES through the literature (Conway, 1987; Crawford et al., 2007a; Darnhofer et al., 2016; Moller et al., 2008). As an SES facing a turbulent environment, farming systems need to be productive, stable, and resilient (Conway, 1987, 1993; Goulden et al., 2013). Being resilient is more than the ability to buffer shocks and return to the previous pattern; instead, to be resilient, it is required to adapt and change through experiencing disturbances (Folke, 2006; Walker et al., 2004). These characteristics introduce attributes of a resilient farming system which are described in the following section.

2.3.2 Resilience attributes for a farming system

Building resilient farming systems needs the development of a farming system's buffer capacity and its transformability as well as its (farmer's) adaptive capacity (Béné et al., 2012; Crawford et al., 2007b; Darnhofer, 2014). To be adaptive, farmers learn about the variation in the environment continuously and a variety of changes can be considered for farming systems depending on the contexts of that farming system (Darnhofer, 2014). Considering the turbulent environment for farming systems, adjustment while keeping the goals and values along with preparedness to experience a fundamental change is required (Darnhofer, 2014). Thus, to cope with turbulent changes, the importance of the adaptive capacity for a farming system comes to the fore.

At the farm level, like every SES, the first attribute of resilience is the farming system's capacity to absorb change or its buffer capacity (Milestad & Darnhofer, 2003). The buffer capacity of a farming system has been defined as the amount of change the farming system can bear and still preserve its current basic structure (Crawford et al., 2007b). Other farm management scholars have also defined buffer capacity in a similar way, e.g., 'the ability to absorb change' (Conway, 1993; Milestad, 2003) or keeping previous patterns of behavior when a system absorbs external changes (Kaine and Tozer, 2005). Therefore, the buffer capacity of a farming system mainly depends on its ability to re-allocate its resources and maintain the farming system while facing a disruption (Darnhofer, 2014; Milestad, 2003). For example, a dairy farming system utilises its financial reserves to import supplementary feed to absorb a disturbance such as a deficiency in pasture availability (Crawford et al., 2007b). This capacity enables a farming system to cope with small disturbances and low-intensity changes (Darnhofer, 2014). To cope with large disturbances, buffer capacity may

not be enough, and adaptive and transformative capacities may be required (Béné, 2013; Darnhofer et al., 2016).

In contrast to buffer capacity, which is the ability to absorb changes, transformability is another attribute of a resilient SES which comes with implementing radical changes to create a fundamentally new system when the ecological, economic, or social conditions are untenable for the existing system (Walker et al., 2004). Transformability includes forward-looking decisions to renovate a (farming) system to a fundamentally different system, which is potentially more beneficial (Chapin III et al., 2010; Shadbolt et al., 2013). This capacity plays an important role in the long-term view of a farming system facing crises (Darnhofer, 2014). Based on the capacity of transformation, farmers are able to rebuild the business in different ways either through non-farming or another farming business (Darnhofer, 2014; Shadbolt et al., 2013). Examples of transformations for farm management have been reported in the literature. For instance, Chirozva (2015) reported that farmers in Zimbabwe changed the cattle and rangeland farming system into ecotourism operations (non-farming business). This fundamental change has been a result of facing governmental acts such as fencing. Similarly, Shadbolt et al. (2013) described a change from sheep and beef farming to dairy farming (another farming business) in New Zealand as an example of transformability. The conversion to dairy farming has been the result of some fundamental changes in New Zealand's agricultural structure[3] combined with a strong market for dairy along with the creation of Fonterra, which helped consolidate the dairy industry (Forney & Stock, 2014).

The long-term view of a farming system facing crises and different degrees of change brings to the fore, that in addition to the ability to bounce back from a shock, a farming system needs to change and bounce forward in some conditions (Darnhofer, 2014; Shadbolt et al., 2013). It has been mentioned that 'bounce forward' encompasses both transformability and adaptive capacity by adapting, improving, and thriving (Cawthorn, 2013; Meerow & Stults, 2016). However, when the main goal is not creating a fundamentally new system, adaptive capacity is of importance for a resilient SES that helps the system to have an incremental adjustment without a fundamental change of the existing system (Béné et al., 2012). In the same way, trying to keep the main goal of farming system, adaptive capacity is a key

[3] Subsidies for sheep farming got removed and the sheep sector declined (Vitalis, 2007).

component of resilience because the management of ongoing changes is an inseparable part of farm management (Darnhofer et al., 2016; Darnhofer et al., 2010b). The capacity of an incremental adjustment is based on the premise that any disturbance may create an opportunity for innovation and development (Darnhofer, 2014; Folke et al., 2005). For example, the experience of uncertainty helps to create awareness of different changes such as droughts, floods, and diseases for a farmer. These experiences can provide an opportunity to conceptualise the likely risk of events and learn from them to anticipate the impacts of future events (Endfield, 2012). To explore the attributes of resilience for SESs, it is necessary to know that changing environments are different for each SES (Gunderson, 2009). The nature of change has been described more elaborately in organisational management literature that provides insight into the turbulent environment that businesses are experiencing these days. Performing in a turbulent environment also highlights the importance of adaptive capacity. The next section is about the nature of disturbances in organisational management followed by the definition of disturbances in farming management literature.

2.3.3 Nature of disturbance

The nature of disturbances is a key issue with resilience, especially with the adaptive capacity which is an attribute of resilient SESs (D. R. Nelson et al., 2007). It is important to identify the source of change, for example, daily changes of production or unexpected changes in the market (Duchek, 2020). Adaptation is often imposed on a SES from undesirable or desirable external changes like climate change (Jacobs et al., 2015) or volatile markets (Hedlöf & Janson, 2000). Undesirable and desirable external changes are well defined in organisational management with the concept of a turbulent environment in which an organisation or a business interacts dynamically with the environment (Emery & Trist, 1965; McCann, 2004; Selsky & McCann, 2008). Rapid technological change and interdependence among organisations are the source of a turbulent environment (Emery & Trist, 1965; Emery, 1976). Global competitors and volatile markets, also, are other sources of the turbulent environment (Hedlöf & Janson, 2000). Due to the turbulent environment, there is a gross increase in uncertainty and unpredictability for an organisation (Emery & Trist, 1965). Coping with uncertainty and unpredictability requires achieving acceptable performance by developing more capabilities (McCann, 2004). To do this, organisations

should be able to manage the variability or challenging circumstances the environment imposes on them or adapt to the requirements of the changing environment (McDonald, 2017). First, the turbulent environment requires organisations to react swiftly in response to external pressures (Emery & Trist, 1965; McCann, 2004; Riolli & Savicki, 2003; Yilmaz Borekci et al., 2015). Second, the literature shows that the external pressure due to a turbulent environment has fundamentally shifted from a predictable series of connected changes to more unpredictable and disruptive changes (McCann, 2004; McCann et al., 2009; Selsky & McCann, 2008). To cope with disruptive changes, different adaptive strategies and capabilities are required to manage changes (McCann et al., 2009). Figure 2.3 illustrates three types of changes in the turbulent environment introduced in the literature; episodic, continuous, and disruptive changes (McCann, 2004; McKnight, 2013; Weick & Quinn, 1999).

Figure 2.3: Types of turbulent environmental change

Source: McCann (2004)

The episodic change, also known as routine change, is infrequent and discontinuous which is intentional (McCann, 2004; Weick & Quinn, 1999). For example, when an organisation is moving away from its equilibrium, a change that resulted from a technological change or a change in key personnel, it experiences an episodic change (Weick & Quinn, 1999). The second type of turbulent environmental change is continuous change, which is constant, evolving, and cumulative (McCann, 2004; Orlikowski, 1996; Weick & Quinn, 1999). With the acceptance of change as a constant, an organisation needs to have a mindful construction of current responses rather than the application of routine past responses (Wheatley, 2011).

Farming systems are good examples of experiencing continuous changes. Changes may occur in biophysical properties, ecological processes, economic variables, characteristics of individuals, and social dynamics (Darnhofer et al., 2012). To manage these changes in farming systems, learning and continuous improvement of knowledge are necessary (Plummer, 2009). The third and the most recently defined type of turbulent environmental change, which organisations encounter nowadays, is disruptive change (McCann, 2004; McKnight, 2013). McCann (2004) defined disruptive change as severe shocks and surprises that can destabilise entire industries and economies in a matter of hours or days. In addition, this kind of change, at an organisational level, can be a consequence of external fast-changing environments such as disruptive technologies, globalisation, capital flows, and alliances that are creating a highly dynamic business environment (Ahn et al.,2004; McKnight, 2013). Most organisations are now experiencing a significant transition from episodic and continuous change, to disruptive change; hence different adaptive strategies and capabilities are needed to manage the above-mentioned changes (McCann et al., 2009).

The ability to quickly recognise and respond to rapid changes, including episodic and continuous changes in the environment to manage organisational performance is described as an organisation's agility (McCann, 2004; Tallon & Pinsonneault, 2011). To achieve agility for an organisation, it is necessary to have a continuous investment in technology, systems, and, particularly, in people (McCann, 2004). Most of the skills that are required for agility are reported in psychological and change-management studies (McCann et al., 2009). In addition, there is another capability that enables the organisation to learn and seize opportunities while facing and managing not only continuous changes but also increasingly disruptive changes (McCann, 2004). The capacity for learning and adaptation of a system is termed its adaptive capacity (Walker et al., 2002). Adaptive capacity is important for an organisation or a system facing disruptive changes (McCann, 2004; Winnard et al., 2014). This capacity is important since it helps to take performance hits but retains the main function of the organisation (McCann, 2004; McCann et al., 2009). Organisational agility is different from organisational adaptive capacity since an organisation's reaction to a rapid change is different from its reaction to a disruptive change (Hamel & Valikangas, 2003; McCann, 2004). For agility, an organisation needs to have a continuous investment in technology, systems, and particularly in people, however, for adaptive capacity the ability to

learn and relearn is prominent (McCann, 2004). This ability of learning helps to acquire new knowledge, re-assemble existing knowledge, and then quickly and effectively deploy that knowledge as new skills and practices facing disruptive changes (McCann, 2004).

The nature of disturbances for farming systems can be described as a turbulent environment since farming systems are facing an increasingly turbulent context and growing uncertainty (Darnhofer et al., 2016; Gray et al., 2008). Thus farmers need to maintain the goals and values of the farming system while adjusting and developing which describes the adaptive capacity of the farming system (Darnhofer, 2014). As such, resilience and adaptive capacity in farm management require an exploration of the nature of disturbance for farming systems. Below, the disturbances for farming systems are described.

2.3.4 Disturbances for farming systems

Different systems experience different types of disturbances within their environment. Farming systems are defined as SESs facing disturbances (Andersson et al., 2015; Darnhofer, 2010). Facing a turbulent environment, farmers need to manage disturbances over both the short-term and the long-term (Darnhofer, 2014; Perrin et al., 2020a; Spiegel et al., 2020). A variety of changes can be considered for farming systems, which help them develop the attributes of their resilience, depending on the contexts of that farming system (Darnhofer, 2014). In the literature for farming resilience, disturbances are classified into sudden shocks and long-term changes named stresses (Darnhofer, 2014; Meuwissen et al., 2019). These disturbances are called risks and uncertainties for the agricultural system[4] and are expanded in different ways. Baquet (1997) classified disturbances into production, marketing, financial, legal, and human risks. Boehlje, Gray, and Detre (2005) divided the source of disturbances as the source of uncertainties into tactical/operational and strategic risk and uncertainties. Tactical/operational risk and uncertainty include production and financial aspects of farming activities that are easier to manage. In contrast, strategic risk and uncertainties include changes from the environment that impose a change in the strategic direction of the farming system. For example, political, macro-economic, social changes, or

[4] Making a decision happens under three conditions of knowledge: perfect knowledge, risk, and uncertainty (Langlois & Cosgel, 1993). With perfect knowledge, the outcome will be certain, while under the condition of risk, the outcome is not certain, but it can be estimated to some extent. Uncertainty is the condition that probable outcome is unknown (Bradtke, 2007; Hardaker, 2004). Due to the nature of agriculture, most farm management decisions involve risk and uncertainty (Gray et al., 2008).

industry dynamics of input/product markets are strategic uncertainties. Recently, the disturbances for farming systems are divided into shocks and stresses while considering four aspects of environmental, economic, social, and institutional by Meuwissen et al. (2019) shown in Table 2.1. Each aspect includes both shocks and stresses. The study is for Europe, however, because of the risky nature of agriculture, most disturbances are suitable for farming systems in other countries as well.

Table 2.1: Examples of disturbances in environmental, economic, social, and institutional aspects for farming systems

Disturbances	**Environmental**	**Economic**	**Social**	**Institutional**
Shocks	- Extreme weather events (droughts, frost, floods) - Pest, weed, disease outbreak	- Price drops for outputs and price spike for inputs - Food and feed safety crisis - Change in interest rates	- Peaks in media reporting on food safety/pests/disease issues - Sudden change to on-farm social capital (illness, death, divorce) - Insufficient availability of seasonal labor	-Sudden change in access to markets - Bans (e.g. using pesticides) - Sudden changes in regulations
Stresses	- Soil erosion - Climate change - Pollution - Hydro-geological disturbances - Loss of habitats - Gradual settlement of invasive species	- New competition in markets - High costs - Resource fixity leading to 'locked-in situation' - Increased cost of hired labor -Loan availability - Fake news - Changes in upstream and downstream market power along the value chain	- Stress regarding ownership and the succession of the farm - Access to social services - Public distrust towards agriculture - Change in: Commitment to cooperatives consumer performance	- Wars, conflicts, and international instability - Changes in: Environmental regulations Restrictive standards Production control policies Regulations in destination markets

Adapted from Meuwissen et al. (2019)

To cope with the disturbances in a farming system, three aforementioned attributes of resilience are required (Darnhofer, 2014; Meuwissen et al., 2019; Spiegel et al., 2020). Then again, developing the attributes of resilience depends on the intensity of change that a system bears, and the degree of the system's response shown in Figure 2.2 (Béné et al., 2016c). Farmers learn about variation in the environment and develop their buffer capacity in a relatively stable environment, over time (Darnhofer, 2014). However, there are some completely new events such as volatility in the output price level, extreme weather events, the introduction of new regulations, and so forth, that require adjustment and development while the underlying goals and values of the farming system remain unchanged (Darnhofer

et al., 2016). To cope with both shocks and stresses, a farming system needs to bounce forward by increasing adaptive and transformative capability (Darnhofer, 2014). Where shocks have temporary effects or irreversible effects that can lead the system to transformation, accumulation of stresses also leads the system to the threshold of transformation (Darnhofer, 2014; Meuwissen et al., 2019). However, when the main goal is managing shocks and stresses without changing the structure and feedback mechanisms of the farming system, the importance of adaptive capacity comes to the fore (Béné et al., 2016c; Meuwissen et al., 2019; D. R. Nelson et al., 2007).

2.3.5 Adaptive capacity in farm management

Among the three attributes of resilience, adaptive capacity plays an important role in resilient farming systems since this capacity enables the farming system as an SES to cope with a certain degree of environmental change that buffer capacity is not able to respond to (Folke et al., 2010; Meuwissen et al., 2019; D. R. Nelson et al., 2007). Also, to cope with a higher degree of change, adaptive capacity is required, which enables the farming system, to respond and adjust itself to a major shift in the environment and get ready to transform when necessary (Béné et al., 2014; Spiegel et al., 2020).

Firstly, adaptive capacity is the ability of a farmer to adjust, which requires the ability to identify changes, establish priorities, combine experience and knowledge, and respond to changing contexts with different management approaches (Darnhofer, 2014). In this vein, Milestad and Darnhofer (2003) and Senyard et al. (2014) argued that learning how to make productive use of unforeseen change through ongoing experiments will improve a farming system's adaptive capacity. Since the behaviour of individual actors is a significant part of a complex adaptive system’s management (Rammel et al., 2007), the role of the farmer is influential within a farming system (Darnhofer et al., 2008; Gray et al., 2008; Milestad et al., 2012). The farmer’s characteristics, management approach, and capability for learning help them to improve their management ability and their capability for adapting to changes (Milestad, 2003; Milestad et al., 2010). Secondly, adaptive capacity is not only the ability of a farmer in a farming system (as an SES) to adjust but, according to D. R. Nelson et al. (2007), the adaptive capacity also helps an SES to be prepared for a deliberate transformation and

avoid a collapse. To encompass the features of an adaptive farming system, a definition of adaptive capacity can be helpful for the rest of the current study.

To define adaptive capacity in farm management, the definition by Bettini et al. (2015, p:47) covers the features of adaptive capacity: The farmers' "ability to mobilise and combine different capacities within a system, to anticipate or respond to economic, environmental, and social stressors, in order to initiate structural or functional change to a system and thereby achieve resilient or transformative adaptation". This definition is selected for this study because it considers multiple disturbances as stressors and emphasises the role of human agency (farmer) to respond to the disturbances through management approaches.

It is understood that the world has changed for dairy farmers in New Zealand (Gray et al., 2008; Shadbolt et al., 2013). However, the change is not so significant that the system must transform. Therefore, dairy farmers do need to make significant changes to adapt the existing system. This research aims to develop metrics to assess and measure perceived adaptive capacity of dairy farmers in New Zealand, after choosing a definition it is necessary to explore adaptive capacity measurement in the literature. The exploration of the resilience literature of SESs, the measurement of resilience in general, and the measurement of adaptive capacity, in particular, are described in the following sections.

2.4 Measuring the resilience of farming systems

One necessary step to a better understanding of resilience is the measurement or empirical analysis of the concept (Béné, 2013). However, resilience is not a physical component of the system, rather an emergent property that is difficult to measure (Bettini et al., 2015; Fletcher et al., 2006). Moreover, the multi-faceted nature of resilience has made its measurement complicated (Béné et al., 2016c; Cumming et al., 2005; Jamero et al., 2018; Thapa et al., 2016). The measurement of resilience has been investigated through the literature with some efforts to lessen its complexity to measure (Jamero et al., 2018). Measuring the resilience of farming systems has been explained via two common perspectives in the literature (Darnhofer, 2010; Darnhofer et al., 2016; Jones & Tanner, 2015).

One perspective focuses on structures that highlight the role of farming system types and ecological dynamics, while the other perspective focuses on social actors and their actions in farming systems (Darnhofer et al., 2016). Research that has focused on structures investigates cause-effect relationships based on variable-driven analyses and seeks to identify structural factors that inherently convey resilience (Darnhofer et al., 2016; Li et al., 2019; Todman et al., 2016). Therefore, it is an attempt to model a system's behavior and to identify an objective measurement of resilience (Darnhofer et al., 2016; Jones & Tanner, 2015; Perrin et al., 2020b). Since the resilience of an SES is not directly observable, an objective measurement must be inferred indirectly by choosing socioeconomic variables (Carpenter et al., 2001; Jones, 2018). By clarifying an underlying cause and a measurable effect, this perspective imposes a reductionist framework upon the complex webs of knowledge, values, and meaning that can affect resilience (Darnhofer et al., 2016; Weichselgartner & Kelman, 2015). Thus, this perspective can indicate a lower resilience of a system. For example, when the assessments tend to focus on one aspect of the farming systems rather than considering the whole farming system (Perrin et al., 2020b).

In comparison to the structural perspective, the other perspective focuses on social actors and their actions by putting them at the center of the analysis (Darnhofer et al., 2016; Jones & Tanner, 2017). Focusing on social actors assumes that the resilience of a system is not only based on the dynamics of that system but that it is also based on broader social structures within which the system operates (Darnhofer et al., 2016; Meuwissen et al., 2019; Perrin et al., 2020b). Thus, the social structure including the perceptions and values of social actors (farmers) can shape the farming system's resilience (Béné, 2013; Darnhofer et al., 2016). In other words, people or social actors are not passive recipients of external changes but their perceptions about the process of changes shape the system's resilience (Jones & Tanner, 2017). Farmers, who manage the farming systems, are central social actors of the farming system (Béné et al., 2016c; Cumming et al., 2005; Jamero et al., 2018; Thapa et al., 2016). Since the farming system is composed of the physical farm and the farmer who manage the farm, the farmers' subjectivity matters (Darnhofer, 2010; Perrin et al., 2020b). They have a legitimate understanding of their situation, the farm business's capacities, and the constraints (Jones & Tanner, 2017; Perrin et al., 2020b). When farmers make sense of threats and opportunities to generate activities, it demonstrates that farmers are actively

facing changes and that they are creatively adapting or transforming their farms (Darnhofer et al., 2016). Therefore, given that farmers are constrained by the structure of the farming system and, or its context, their implementation of activities in the face of change can differ significantly because of their different perceptions (Béné, 2013; Darnhofer et al., 2016; Jones & Tanner, 2017). As a result, the second perspective, which is focused on social actors and their actions, provides a subjective measurement of resilience. This measurement is a move from a variable-driven objective measurement method towards an actor-oriented subjective measurement method (Jones & Tanner, 2017; White, 2010). Both these perspectives, the objective and the subjective measurement, are also seen when utilising the two instruments of measuring resilience: surrogates and indices.

2.4.1 Resilience measuring instruments

Two instruments of measuring resilience have been introduced in the literature; using surrogates or using indices (Carpenter et al., 2005; Schwarz et al., 2011; Worstell & Green, 2017). Surrogates are the important aspects of resilience related to the theoretical notion of resilience in a particular SES that are not directly observable but must be inferred indirectly (Carpenter et al., 2005). In contrast, considering some direct observable key indicators under a theoretical conceptual framework and grouping them makes an overall or composite index (Rose & Krausmann, 2013).

Measuring resilience is possible through the use of surrogates as an indirect measurement (Bennett et al., 2005; Berkes & Seixas, 2005; Carpenter et al., 2005). Surrogates are often context-dependent and related to the circumstances that the SES experiences (Carpenter et al., 2005). In ecosystems and SESs, surrogates usually are chosen from biophysical or socioeconomic characteristics of a system that may change over time (Carpenter et al., 2005). There have been efforts to identify different surrogates for different systems using a case study approach (Anderies et al., 2006; Biggs et al., 2012; Cabell & Oelofse, 2012; Folke et al., 2003; Walker et al., 2006). In the farm management literature, there have been some attempts to measure the attributes of resilience utilising surrogates. For instance, Shadbolt et al. (2013) utilised key performance indicators (KPIs) as surrogates to measure the New Zealand dairy farmers' resilience, which sits in the objective measurement method. In another study, Perrin et al. (2020b) introduced farmer's satisfaction (of farm converting to

organic farming) as a surrogate of farming system's resilience to multiple disturbances, which sits in the subjective measurement method. Objective and subjective methods are described in next sections.

In contrast to surrogates that are an indirect indicator of SESs resilience, another instrument is constructing an index which is potentially useful for assessing the many observable dimensions that make a system resilient or adaptable (R. Nelson et al., 2010; Rose & Krausmann, 2013; Worstell & Green, 2017). An empirical assessment of resilient multi-faceted attributes (e.g. adaptive capacity) mostly sits in the index designing methods (Rose & Krausmann, 2013; Speranza et al., 2014; Vincent, 2007). The construction of an index firstly needs the conceptual framework in which different indicators are counted for different dimensions of the attribute of resilience (Asmamaw et al., 2019; R. Nelson et al., 2010; Rose & Krausmann, 2013). There have been some attempts to measure the attributes of resilience utilising indices within the objective conceptual frameworks. For instance, R. Nelson et al. (2010) constructed an adaptive capacity index using data provided by farmers through the Australian Agricultural and Grazing Industries Survey. However, constructing an index within the subjective conceptual frameworks is not often seen in the literature.

2.4.2 The subjective versus objective measurement

Literature on resilience measurement in general and adaptive capacity measurement in particular shows that there have been efforts to determine frameworks and methods of selecting indicators or surrogates to do the measurement (Bennett et al., 2005; Cabell & Oelofse, 2012; Carpenter et al., 2005; Cutter et al., 2010; Tinch et al., 2015). In this vein, there has been a number of frameworks and approaches developed for quantifying the resilience of different systems (Bahadur et al., 2015). However, since the assessment of resilience is complex and there is no way of directly measuring, its measurement methods have been challenging (Béné, 2013; Cumming et al., 2005; Jones, 2018). One of the challenges is that the early measurement efforts of resilience in the literature are focused on the use of objective measurement frameworks relying on socioeconomic data (Jones, 2018; Jones & Tanner, 2017). However, with a much shorter history, subjective measurement of resilience emerged in the early climate literature and social resilience relying on perception-based methods (Marshall & Marshall, 2007; Miller et al., 2010; Twigg,

2009). In the subjective measurement, instead of using external observation, respondents are asked to rate their perceptions and preferences (Béné et al., 2016b; Maxwell et al., 2015). This is because people are decision-makers and have a legitimate understanding of their situation (Jackson, 2005; Perrin et al., 2020b). Thus, their perceptions matter in the way that how they see reality when it comes to measuring their resilience (Béné et al., 2016b; Jackson, 2005; Jones, 2018).

Likewise, measuring adaptive capacity, as an attribute of resilience in SESs (Folke et al., 2003; Walker et al., 2004), is not easy to capture without considering the human decision-making ability (Engle, 2011). Although there have been efforts to measure the adaptive capacity using objective frameworks (Adger et al., 2009; Engle, 2011; R. Nelson et al., 2010; Smit & Wandel, 2006), this type of measurement has not been able to consider the human involvement with their decision-making in social-ecological systems properly (Brown et al., 2010; Jones & Tanner, 2017; Park et al., 2012). While objective approaches have their advantages in adaptive capacity measurement, the weakness of not considering the main decision-makers of SESs in these methods leads to an alternative method, subjective measurement (Grothmann & Patt, 2005; Jones & Tanner, 2015; Thapa et al., 2016). Utilising this subjective method is of interest for this study and the dimensions of adaptive capacity perceived by a dairy farmer (decision-maker). The next sections elaborate more on objective and subjective measurements.

2.4.2.1 Objective measurement

The objective measurement of resilience is independent of the subject's judgment and relates to the external observation of resilience characteristics by the researcher or the evaluator instead of the assessed people's viewpoint (Jones, 2018). The objective approach of resilience requires a range of observable socio-economic variables to be selected as indicators or surrogates that illustrate the resilience of the system (Jones & Tanner, 2017; Xu et al., 2015). For example, calculating water provision resilience, by choosing six critical aspects of urban water supply systems, is a measurement of the urban water systems' ability to adapt to change and continue to function over a long-time span (Milman & Short, 2008). However, choosing the correct and appropriate variables needs to be explored and has been a challenge for this approach (Carpenter et al., 2001; Jones & Tanner, 2017). The selection of variables mostly dictates the researcher's understanding of resilience for

specific people, communities, or SESs (Béné et al., 2016b; Clare et al., 2017; Jones, 2018). Moreover, there is a fact that some attributes of resilience in social-ecological systems are not directly observable (Béné et al., 2016b; Carpenter et al., 2001). For example, adaptive capacity is an attribute of resilience that has been described as a decision-making process to mobilise and combine different capacities within a system and a set of actions undertaken to deal with disturbances (Bettini et al., 2015; Brown et al., 2010; D. R. Nelson et al., 2007). Therefore, adaptive capacity is not directly observable as a socio-economic indicator or surrogate. When the decision-making ability of humans who are involved in social-ecological systems is not considered, the focus would be on constraints such as financial and technical constraints for describing the primary determinants of adaptive capacity (Grothmann & Patt, 2005). However, decision-making is an important part of adaptive capacity (Brown et al., 2010; Jones & Tanner, 2017; Park et al., 2012). Thus, recently, the subjective measuring approach has started to be more explored via considering people's viewpoint and perceptions when resilience or adaptive capacity is assessed or measured (Béné et al., 2016b; de Villiers et al., 2014; Jones & Tanner, 2015; Nettle et al., 2018; Thapa et al., 2016).

2.4.2.2 Subjective measurement

The involved people's perceptions and values can strengthen or weaken the system's resilience (Béné et al., 2016b; Darnhofer et al., 2016; Jackson, 2005). Also, considering behavioural psychology and social science, people's perceptions about reality play an important role in their decisions (Béné et al., 2016b; Jackson, 2005). Subjective measurement of resilience is related to the decision-maker's understanding of the environment and perceptions of their ability to cope with disturbances (Jones, 2018). Thus, it can be said that considering subjectivity is a way to complement the embedded weakness in the objective measurement in which the external observations were the core of measurement (Jones, 2018; Jones & Tanner, 2017). For measuring any aspect of SESs' resilience at different levels, subjectivity matters (Perrin et al., 2020b). For example, a farming system includes the farmer and the physical farm including land, animals, crops, and machines. The farmer is in the centre, who decides about the whole farming system (Darnhofer, 2010). Subjectivity originates from the fact that decision-makers, such as farmers, have a legitimate understanding of their situation and the factors that contribute to constrain the system's capacities that they are involved with (Jones & Tanner, 2017;

Perrin et al., 2020b). Also, people's ability to anticipate future disturbances (e.g. stresses) makes them capable of taking adaptative responses to lessen the perceived negative impacts of future events (Engle, 2011). This ability of anticipation and choosing adaptative responses has been introduced as the psychological aspect of adaptation (Grothmann & Patt, 2005). Thus, the subjective measurement relies heavily on psychological resilience and risk perception literature (Jones, 2018).

2.5 Measuring adaptive capacity

Adaptive capacity is an attribute of resilience (an emergent property of a system), so it cannot be measured directly (Fletcher et al., 2006; Gray et al., 2008). It is the way of managing an SES (de Villiers et. al., 2014) when managers try to maintain the resilience of SESs by developing adaptive capacity (Walker & Salt, 2006). The literature on assessing adaptive capacity has grown in the last decades (Bettini et al., 2015; Engle, 2011; Thapa et al., 2016). The assessment of adaptive capacity is about investigating the ability of SESs to adjust to new conditions after disturbance while taking advantage of changes (Berkes et al., 2008). In this vein, D. R. Nelson et al. (2007, p.396) described adaptive capacity as a "decision-making process and the set of actions undertaken to maintain the capacity to deal with current or future predicted change". The measurement of adaptive capacity follows approaches in which the main components of adaptive capacity are introduced: a capital-based approach emphasising five capitals or a process-based approach emphasising decision-making (Thapa et al., 2016). The first approach is based on a sustainable livelihood framework usually applied at the individual and household levels (Huai, 2016; Lemos et al., 2016; R. Nelson et al., 2010; Shivakoti & Shrestha, 2005). While the second approach is based on decision-making which emphasises flexibility in making decisions and learning through activities (Cox, 2014; Dutra et al., 2015). The later approach broadens the scope of human and social capital practices in adaptive capacity that are important in decision-making (Nettle et al., 2018; Thapa et al., 2016).

Combining adaptive capacity and subjectivity leads to the identification of the concept of "perceived adaptive capacity". This is because of the nature of adaptive capacity that cannot be measured directly before happening. In addition, making decisions contributes to adaptive capacity. Therefore, instead of adaptive capacity, it is the farmer's perceptions of their adaptive capacity that is going to be measured. This is based on the assumption in

behavioural psychology and social science that decisions are often, if not always, based on an individual's perceptions of reality, and not reality per se (Bandura, 1977; Béné et al., 2016b; Jackson, 2005). Thus, perceived adaptive capacity takes into account the importance of farmer's perceptions to manage undesirable and desirable disturbances. There is similar work in the risk area in the literature where there is a relationship between farmer's self-assessment of their management skills and their risk-taking attitude (Patrick, 2013; Shadbolt & Olubode-Awosola, 2013). In this study, both capital-based and decision-making approaches are explored together to develop a conceptual framework and a measurement tool for the perceived adaptive capacity of New Zealand dairy farmers.

2.5.1 Five-capitals framework

The five-capitals framework originates from the sustainable livelihood framework (SLF) where five diverse forms of capital; natural, physical, financial, human, and social capital are considered to assess household adaptive capacity facing disturbances (Ellis, 2000). The five capitals for households are defined in different studies (Bebbington, 1999; DFID, 1999; Ellis, 2000; Scoones, 1998) shown in Table 2.2. Households are in the context of rural development while farming systems refer to the farming business. Regarding that the farming systems mostly include households, the explanation of capitals for households also explains these capitals for farming systems. The definition and description of sustainable livelihood can illuminate the five-capitals framework to assess adaptive capacity.

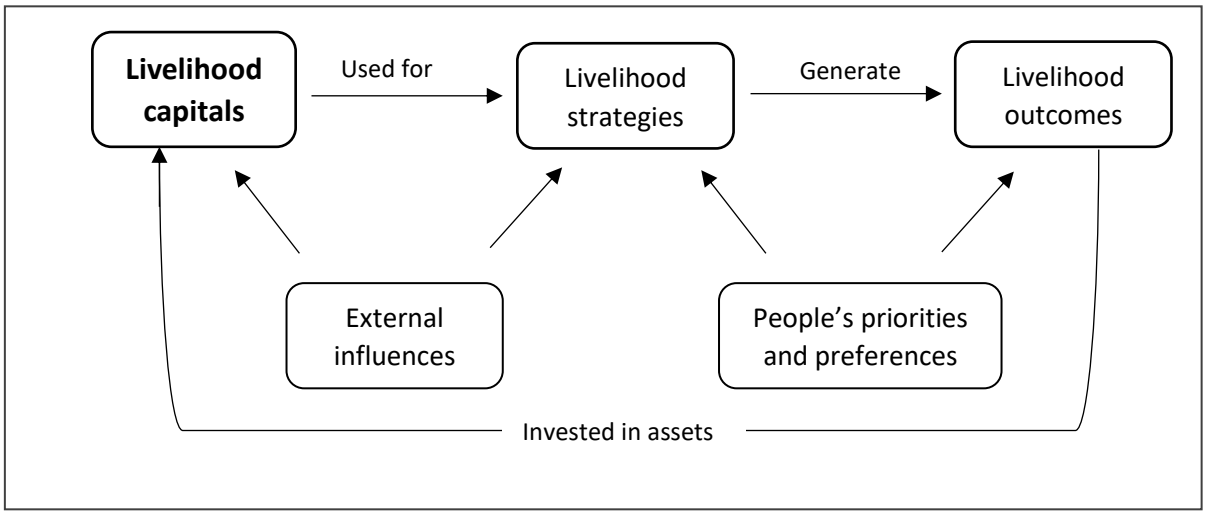
Table 2.2: Description of five capitals for livelihoods

Capital Type	**Description**
Natural capital	Land, water, weather, topography, and biological resources
Physical capital	Infrastructure, equipment, livestock, and technology
Financial capital	Savings, credit, debt, and equity
Human capital	Education, skills, management capacity, and health
Social capital	Formal and informal social resources, social involvement and interactions,

Adapted from Bebbington (1999), DFID (1999), Ellis (2000), and Scoones (1998)

The SLF has been central to rural development thinking and practice including the activities and interactions with emphasise the diversity of ways people make a living (Scoones, 2009). The SLF has been used in developing countries with smallholder farmers as a unit of analysis (Ellis, 2000). Livelihood resilience depends on the capacity of the household to cushion the stresses and disturbances it is exposed to; while maintaining or improving its essential capitals and functions (Luttrell, 2001; Tanner et al., 2014; Wiesmann et al., 2011). Coping with and recovering from stresses and shocks (external influences) enables a livelihood to continue and sustain (DFID, 1999). Figure 2.4 shows a simplified SLF.

Figure 2.4: Simplified Sustainable livelihoods framework



Source: Adapted from Ashley & Carney (1998)

The SLF has been applied to livelihood studies with a focus on adaptive capacity (R. Nelson et al., 2010; Plummer & Armitage, 2010; Tanner et al., 2014). In livelihood studies, the households face a vulnerability context (external influences) which includes shocks, stresses, and trends where the households must cope (Cobbinah et al., 2015; DFID, 1999; Ellis, 2000). From the resilience perspective, the coping strategies used by the households in a time of crisis are consistent with the concept of buffer capacity because they provide the capacity to cushion the impacts of sudden and unpredictable changes (Speranza, 2013). In addition, households face an increasing trend of conversion coping with overwhelming shocks (DFID, 1999). These types of changes lead to the concept of adaptive capacity and the transformability of livelihood resilience (Cobbinah et al., 2015). Consequently, adaptive strategies are required to enable the households to minimise the failure of predictable long-

term changes in livelihood and spread risks during the time to achieve livelihood outcomes (DFID, 1999; Ellis, 2000; Oparinde and Hodge, 2011).

Adaptive capacity in the sustainable livelihoods framework mostly focuses on the household's capitals from which adaptation actions can be made (Smit & Wandel, 2006; Vincent, 2007). According to Rakodi (2014), households are considered rational decision-makers that have access to capitals. On this basis, Scoones (1998) uses the term 'adapt' to refer to longer-term shifts in livelihood strategies that are inevitably necessary to achieve a sustainable livelihood. In addition, the literature indicates that the interrelationships of livelihood capitals and livelihood outcomes are not easy to generalise because every household has a unique and changing set of capitals and strategies to attain their unique intended outcome (DFID, 1999; Ellis, 2000; Hebinck & Bourdillon, 2001; Soini, 2005). Thus, it can be said that the livelihood adaptive capacity is a context-related concept demonstrating the ability to adapt to changes (Lemos et al., 2016; Smit & Wandel, 2006). This capability comes from the reliance on the household's ability to anticipate change and identify new or modified livelihood opportunities through their access to the capitals (Vincent, 2007).

Since the ability to adapt to change mostly depends on the household's capitals (Ellis, 2000), adaptive capacity can be measured with a focus on the introduced five capitals (Lockwood et al., 2015; R. Nelson et al., 2010; Nettle et al., 2018). The importance of the capitals has been highlighted for adaptive capacity (Paudel Khatiwada et al., 2017; Speranza et al., 2014). In this vein, R. Nelson et al. (2010) discussed that the adaptive capacity of rural livelihood is an emergent property of the households' diverse forms of five types of capital: natural, physical, financial, human, and social capital. Similarly, Ellis (2000) stated that the adaptive capacity of a household in a livelihood depends on the mix of its capitals from which it is derived. Example studies with a focus on five capitals mostly try to anticipate the impacts of climate changes by prioritising adaptation responses to these changes (Cinner et al., 2018; Lemos et al., 2016; Smit & Wandel, 2006; Tanner et al., 2014). The efforts to focus on adaptive capacity introduce the five-capitals framework that has been used for adaptive capacity assessment and measurement studies in the literature (Lemos et al., 2013; Mayunga, 2007; R. Nelson et al., 2010; Nettle et al., 2018; Thapa et al., 2016).

Moreover, the framework of SLF with a focus on adaptive capacity can be utilised for different units other than households in developing countries (Nettle et al., 2018). Therefore, although in the first place, SLF was designed to assess the household's vulnerability and adaptive capacity, it has been used to measure and characterise adaptive capacity in different studies in the field of farming systems (R. Nelson et al., 2010; Nettle et al., 2018; Thapa et al., 2016). The five capitals for sustainable livelihood and sustainable agriculture are generally defined in the next section.

2.5.1.1 Natural capital

In the literature, the concept of natural capital originates from sustainable development where the assumption is that the future generations must have the same sustainable capacity or potential to meet their needs as the current generations (MacDonald et al., 1999). Thus, the concept of natural capital and the concept of sustainable development are intertwined and the protection of natural capital is a core criterion of sustainable development (Islam et al., 2019). Natural capital is generally defined as any stock of natural resources or environmental assets that yield a flow of valuable goods and services either now or in the future (Costanza & Daly, 1992; Pearce & Turner, 1990). All livelihoods depend on natural capital in general and depend on critical components of natural capital in particular (DFID, 1999). Critical components of natural capital refer to ecological assets that are essential to well-being or survival (Pearce, 2014). Any change in the conditions of natural resources can have a major impact on livelihoods (Scoones, 2009). For example, flooding, earthquakes, or any kind of natural disaster can impact a household's livelihood strategies and outcomes (Pandey et al., 2017).

To consider natural capital in agricultural systems, it is necessary to identify and determine the critical elements that provide valuable goods or services for agriculture (Brady et al., 2015). Agriculture relies on natural resources that provide underlying conditions which allow production and absorbing wastes. These resources may include cropland and pasture land, soil ecosystem, rainfall, or water bodies (Dominati et al., 2010; Islam et al., 2019; MacDonald et al., 1999). Economic valuation of natural capital is not easy since the services provided by natural capital are not easily valued (Bateman & Turner, 1993). Therefore, in the literature, some methods to put an economic value on natural capital include

willingness to pay method or rely on shadow prices (Islam et al., 2019). Other than the pricing methods, it is clear that the protection of soil and water quality, and minimising environmental footprint is crucial for future sustainability (Beukes et al., 2013; Doole & Romera, 2015; Houlbrooke et al., 2009; Yang & Sharp, 2017). Thus, for the natural capital of farming systems, the critical elements following the sustainable development concept are identified as protecting the environment and maintaining soil structure, water quality, minimising environmental footprint, willingness to conserve water, land & other resources for the future generation.

2.5.1.2 Physical capital

Physical capital comprises the basic infrastructure and productive assets such as tools, equipment, and goods that support people to pursue their livelihoods (Morse & McNamara, 2013; Rakodi, 2014). According to DFID (1999), the basic infrastructure components are affordable transport, secure shelter and buildings, adequate water supply and sanitation, affordable clean energy, and access to information (communications). In addition, individuals or groups may own or rent some productive assets or goods (DFID, 1999). Physical capital is important for livelihoods because the infrastructure and the household's productive assets help people meet their basic needs and be more productive both in the short and long term (Ashley & Carney, 1998; DFID, 1999). Although a lack of some types of infrastructure can result in poverty for a household, physical capital itself requires initial capital investment, operation, and maintenance costs that can be expensive for households in the first place (DFID, 1999). Therefore, SLF considers physical capital as household possession of durable assets such as houses, machinery, animals, market, health care facilities, and road transport facilities (Kabir et al., 2012; Rakodi, 2014; Salafsky & Wollenberg, 2000).

As such, investments in assets that support the increase in land, machinery, buildings, tools, water systems, livestock, and so forth are defined as physical capital in agriculture (Berti et al., 2004). This capital also has been defined as manmade capital that encompasses anything developed by human efforts such as equipment and infrastructures (Bongiovanni & Lowenberg-DeBoer, 2004). In some cases, physical capital investment is required for natural capital conservation such as preventing soil erosion (Blaikie, 1985). For example, irrigation

infrastructure instead of flood irrigation helps to prevent soil erosion (Cerdà et al., 2021). Also, physical capital improvement such as enhancing physical infrastructure is observed as assistance to promote sustainable development (Shaw et al., 2013), which also assists to increase adaptive capacity (DFID, 1999). Moreover, considering livestock and pasture quality is a way of physical capital improvement (Berti et al., 2004).

2.5.1.3 Financial capital

Financial capital includes available financial resources such as savings, supplies of credit, or other assets that can be converted into cash either in the short or long term (DFID, 1999; Ellis, 2000). Financial capital enables households to pursue different livelihood strategies and achieve livelihood objectives (DFID, 1999; Ellis, 2000). In addition, people usually use financial resources to cope with extreme events (Bhandari, 2013; DFID, 1999; Pandey et al., 2017). Financial capital is the most versatile and crucial capital for households (DFID, 1999). The importance of this capital originates from its capacity to be easily spent or exchanged into other types of capital such as physical capital (DFID, 1999; Pandey et al., 2017). Some opportunities such as income generation and an effective market may increase a household's financial capital, however, it depends on variability in financial resources in the livelihood region (Pandey et al., 2017). Although financial capital is important and versatile, it cannot provide the capacity of coping with extreme events or disturbances without utilising some or all of the other four capitals and vice versa, which highlights the importance of capital combination for sustainable livelihood (DFID, 1999; Pandey et al., 2017). For example, a lack of knowledge can be an obstacle to put financial resources to good use, while purchasing knowledge with a small amount of money is not possible (DFID, 1999).

Running an agricultural business requires financial capital that is provided through equity, debt, or both (Chandler & Hanks, 1998) and is mostly created by financial profits as a motivation (McDonald et al., 2016; McNall & Mitchell, 1949; Peterson et al., 2012). Thus, considering financial capital with respect to adaptive capacity can be related to the incentives and motivations which influence the decision-making (Gupta et al., 2010). Making the largest possible profit and economic prosperity are two incentives to run a business (Moreira & Bravo-Ureta, 2010; Peterson et al., 2012). From the business performance

viewpoint, profit-making and economic prosperity build the decision-maker's expectations and the business goals, however, certain characteristics of the decision-maker also affect profitability and growth (Danes et al., 2009). In this regard, a set of human capital characteristics, such as management abilities and attitudes toward resource use, help to achieve the financial success of the business (Astrachan & Kolenko, 1994; Danes et al., 2009).

2.5.1.4 Human capital

Human capital comprises the skills, education, capabilities, and health of individuals that contribute to the skill base and performance of households to achieve their objectives (DFID, 1999; Williamson et al., 2012). Human capital theory defines people as a form of capital for development (Becker, 1962; Schultz, 1960). Where education and schooling are counted as an investment that prepares the labour force and increases the performance and productivity of individuals (Nafukho et al., 2004). However, it should be considered that human capital is an extensive concept not only related to education and training but covers many areas from health to migration (Tan, 2014). As such, for a sustainable livelihood, human capital is viewed as the most important household capital because it is critical for productivity and the management of the other four capitals to attain better outcomes (DFID, 1999; Huai, 2016). Thus, human capital has been mentioned as a building block or means of achieving livelihood objectives and sustaining livelihood outcomes (Bhandari, 2013). If a household has access to good quality human capital, it can improve its productivity, income, and the wellbeing of the family if they have good access to the other four capitals (Kaskoyo et al., 2017; Pandey et al., 2017). Therefore, the quality of the human capital within a household influences managing external influences or vulnerability context (Pandey et al., 2017). To find out about human capital it is necessary to consider skills, knowledge, good health, and physical capability which are useful to implement livelihood strategies and achieve livelihood outcomes (Scoones, 2009). In this vein, investigating a variety of elements for human capital was suggested rather than focusing on exact measurement (DFID, 1999). The elements are certain characteristics of individuals including formal education, local knowledge, and the value of their abilities (DFID, 1999; Folloni & Vittadini, 2010).

For a farming system, human capital can be explored through different attributes related to the main decision-maker of the farm. These attributes are described further in this Chapter, Section 2.5.2.3. Also, there is a close relationship between the knowledge embedded in human capital and its transmission, which leads to the investigation of social capital (DFID, 1999).

2.5.1.5 Social capital

Social capital is well-described by Coleman (1988, p.S100) in his seminal paper; "human capital is created by changes in persons that bring about skills and capabilities that make them able to act in new ways. Social capital, however, comes about through changes in the relations among persons that facilitate action". Since it comes with others and is available to the actor only through the relationships, its definition is resources embedded in social structures and networks (Lin, 2002). Also, it has been mentioned that social capital lies first in the fact that it identifies certain aspects of social structure by their functions and this capital is less tangible existing in the relations (Coleman, 1988). Social capital is important for a household because it covers family, friends, and associates that can be called on in a crisis to get a different kind of support such as emotional, managerial knowledge, or financial (Pandey et al., 2017; Woolcock & Narayan, 2000). Thus, social capital can be considered as a stock of social trust, networks, and values that people, individually or in groups, can get support to improve their livelihood and pursue their livelihood objectives (DFID, 1999; Putnam, 2000; Turner, 2007). Social capital can be classified into three types; bonding, bridging, and linking (Szreter & Woolcock, 2004; Turner, 2007). The aspects of social capital are described in Section 2.5.2.4.

2.5.2 Decision-making framework

Farm management requires decision-making when coping with uncertainties (Boehlje et al., 2005). Decision-making in farm management is discussed in the literature (Castle et al., 1972; Damisa & Yohanna, 2007; Gray et al., 2009; Griffin et al., 2008; Solano et al., 2006). To explore decision-making, the concepts of risk, uncertainty, and management practices are important since any decisions in farm management are made under risk and uncertainty and affect management of that system (Huirne, 2003; Komarek et al., 2020). In addition, building resilience in a farming system is the ability to successfully manage risks and

uncertainties (Crawford et al., 2007a). In this vein, a range of attributes for the resilient farmers as the decision-makers also needs to be investigated (Doran et al., 2020; Duranovich, 2015; Findlater et al., 2019). Other than the characteristics of farmers as part of the human capital for the farming system, the decision-making literature emphasises both the decision-makers' interpretation of decision situation and their social capital (Jansen et al., 2013). There has been little focus on conceptualising human capital and social capital in the five capitals framework (Nettle et al., 2018). Considering decision-making in the farm management literature, it can be useful to include risk, uncertainty, management practices, the attributes of decision-makers, and decision-makers' connection to other people.

2.5.2.1 Risk and uncertainty

Making a decision happens under three conditions of knowledge: perfect knowledge, risk, and uncertainty (Langlois & Cosgel, 1993). With perfect knowledge, the outcome will be certain, while under the condition of risk, the outcome is not certain, but it can be estimated to some extent. Uncertainty is the condition that probable outcome is unknown (Bradtke, 2007; Hardaker, 2004). Due to the nature of agriculture, the situation of perfect knowledge is rare in agriculture, therefore, most farm management decisions involve risk and uncertainty (Gray et al., 2008). Although risk and uncertainty can imply negative consequences for farm management such as economic losses or deviation from prior fixed targets, higher expected returns are typically one of the positive rewards for taking risks (Findlater et al., 2019; Komarek et al., 2020). Risks also provide opportunities as well. For example, the introduction of a new technology may impose potential financial stress, however, adoption of new technology and keeping up with new technology often provides opportunities for improving the farming system (Alpass et al., 2004). There are many classifications of risk in farm management literature. However, the five general types of risk and uncertainty in agriculture are related to production, market, institutional, human resources, and financial (Hardaker, 2004; Komarek et al., 2020; Shadbolt & Martin, 2005).

a) Production risk comes from the uncertain natural growth process of livestock and crops including all factors such as climate variation and changes in production yield.
b) Market risk focuses on uncertainty with regard to prices and markets and the factors that affect the level and stability of input and output prices. Domestic and

international markets, demands, trade barriers, and exchange rates are examples of market risks.

c) Institutional risk is related to unpredictable changes linked to future decisions, policies, and regulations that impact agriculture.
d) Human resource risk is associated with individuals' health and personal relationships that affect the farming system such as staff or personal injury and death. This type of risk is very important when the whole farming system's management relies on one farmer or one family unit.
e) Financial risk refers to the uncertainty inherent in farm financings such as farm's operating cash flow, changes in interest rates, finance availability, and changes in the land price.

A list of risks and uncertainties has been introduced in previous studies for New Zealand dairy farming (Duranovich, 2015; Khatami, 2022; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). The list is modified within the abovementioned five types. The management process for a farming system should be emphasised how farmers cope with different sources of risks and uncertainties (Gilbert & Morgan, 2010; Komarek et al., 2020).

2.5.2.2 Management practices

Farmers have different risk perceptions resulting in different decision-making and response to risks known as management practices or management strategies (Duong et al., 2019). Management practices are introduced as one of the components of decision-making that convey how the farmers think in confronting uncertain environments (De Romemont et al., 2014; Lockwood et al., 2015; Small et al., 2016). Farmers rely on a mix of practices to manage risk (Martin & McLeay, 1998), therefore, depending on their perceptions of risk and uncertainty they adopt a different set of contextual management practices (Brown & Roper, 2017; Dang & Pham, 2022; Martin & McLeay, 1998). In addition, management practices are a key dimension for adaptive capacity (Adger et al., 2005; Lemos et al., 2016). The management process for a farming system should be emphasised how farmers cope with different sources of risks and uncertainties (Gilbert & Morgan, 2010; Komarek et al., 2020).

There are studies to define the management practices for farmers which are context-dependent (Hall et al., 2003; Lockwood et al., 2015; Palinkas & Szekely, 2008). Given that

dairy farmers in New Zealand are being exposed to a turbulent environment, there have been some studies defining common management practices for them (Duranovich, 2015; Khatami, 2022; Shadbolt & Olubode-Awosola, 2013). A list of these management practices has been introduced in previous studies for New Zealand (Duranovich, 2015; Khatami, 2022; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). The list is modified for this study regarding ongoing changes happening in New Zealand.

2.5.2.3 Human capital attributes

Human capital can be explored through different attributes related to the main decision-maker of a farming system. These attributes are mostly related to how an individual perceives the world around them, also, are related to the farmers who can capture opportunities when facing disturbances. Perceiving disturbances as a window of opportunity is compatible with the definition of adaptive capacity by Folke et al. (2005).

The first item influencing an individual's perceptions is their family background that defines their career and life success (Filippin & Paccagnella, 2012; Kim, 2014). Other than background, based on the literature there are some attributes relevant for individual resilience (McCann et al., 2009; Price & Leviston, 2014; Rogers et al., 2013). Duranovich (2015) determined six of these attributes, based on literature, in his research including; locus of control, self-efficacy, sense-making, strategic thinking, willingness to accept change, and open-mindedness.

The locus of control is the individual's general expectancy of where control over events and outcomes is located (Rotter, 1966). Rotter (1996) divided people into two groups: with internal or external locus of control. When an individual has an internal locus of control, s/he believes that s/he can find solutions to unexpected problems while an individual with an external locus of control believes that the unexpected events do not come under control easily by her/his solutions (Skodol, 2010). Resilient people are those with an internal locus of control (Marshall et al., 2016; Skodol, 2010) since it influences their decision-making process such as planning and implementation (Marshall et al., 2016; Tanewski et al., 2000; Van Kooten et al., 1986). It is stated that the internal locus of control is positively correlated with farm planning and performance (Tanewski et al., 2000). Also, Marshall et al. (2016) mentioned that the farmers with an internal locus of control can extend their ability to face

fundamental changes and be prepared for transformability. Therefore, the internal locus of control increases the farmers' resilience over the management practice (Duranovich, 2015; Van Kooten et al., 1986). Locus of control has been introduced as closely related to self-efficacy (Price & Leviston, 2014; Skodol, 2010).

Self-efficacy is a belief in one's capabilities to perform a designated level of task to attain goals (Bandura, 1977). It is different from self-confidence since it is task-specific (Lown et al., 2015). Self-efficacy focuses on individuals' capabilities to how one can overcome stressful situations, can successfully perform responses to change, and can influence the challenges of tasks they face (Bandura, 2010; Reich et al., 2010; Schwarzer & Warner, 2013). Resilient people have strong self-efficacy, believing that they can organise and execute the courses of action to achieve their goals (Bandura, 2010). Also, self-efficacy influences future planning for individuals (Azizli et al., 2015). Therefore, an individual with strong self-efficacy sets strong goals and maintains a strong commitment to achieving those goals (Bandura, 2010). People with strong self-efficacy are more likely to perceive a source of risk and uncertainty as an opportunity rather than a threat (Bandura, 1977; Gist, 1987).

Sense-making is mostly seen in defining one's ability to put new situations into perspective and make sense of them (McCann et al., 2009). This attribute describes making sense of a new situation while acting quickly in a turbulent business environment (McCann, 2004; McCann et al., 2009). Also, it is defined in psychology that sense-making is a cognitive behavioural response to ambiguous and uncertain situations out of an individual's experience in the world (Duffy, 1995; Gioia & Chittipeddi, 1991). Thus, when a particular event in the environment takes place, sense-making is a cognitive process of the current situation in the environment which involves a retrospective rationalisation of the actions that an individual wants to take (Klein et al., 2006b). People have their perspectives, viewpoints, and mental models that help them explain the situation and make their decisions (Klein et al., 2006b). The higher the level of sense-making, the more understanding of a situation and that makes it easy for an individual to determine an appropriate course of action for that situation (Boland, 2008). Moreover, social activities enable and enhance sense-making (Weick, 1995).

Strategic thinking in the literature is mostly relevant to individuals, SESs, and organisations' ability to adapt while developing holistic thinking (Darnhofer, 2010; Folke et al., 2010; Gibson & Tarrant, 2010; Walker & Salt, 2006). There is a link between strategic thinking and the adaptive capacity of individuals (Sloan, 2019). SESs requires strategic thinking for the process of adaptation since their ability to implement changes comes from the options that they define by holistic thinking (Ensor et al., 2015). Also, strategic thinking for organisiations, facing turbulent environments, acts as a facilitator of adaptive capacity (Sorgenfrei & Wrigley, 2005). A strategic thinker benefits from five elements: system perspective, intent-focused, thinking in time, hypothesis-driven, and intelligent opportunism (Liedtka, 1998). Liedtka (1998) described the five elements; firstly, it is very important to see how different problems are connected and influence each other and see opportunity or threat as a part of the whole system. Secondly, a strategic thinker is less distracted and more focused in the marketplace. Thirdly, a strategic thinker must be able to connect past, present, and the future by using their memory, understanding of the present situation, and creating their future. Fourthly, developing good hypotheses and testing them efficiently is an essential element in the fast-changing environment. Finally, a strategic thinker needs to be responsive to opportunities which is directly related to the business adaptive capacity by exploiting possible opportunities in a changing environment through emergent strategies. Strategic thinking enhances the adaptive capacity of farmers (Marshall et al., 2014) that can be learned and built by farmers helping them to be proactive (De Romemont et al., 2014).

Willingness to accept changes is an attribute of resilient people who can accept reality (Coutu, 2002). In psychology, it was shown that there is a strong positive connection between optimism and resilience (Souri & Hasanirad, 2011). However, the ability to accept reality is not only about being optimistic rather it prepares people to act quickly when they face unexpected adverse events (Coutu, 2002; Feder et al., 2010). Since willingness to accept ambiguity and uncertainty is linked to the learning ability, it is connected to adaptive capacity (Boxelaar et al., 2006).

Open-mindedness is an attribute defining resilient people who can adapt to changes in the environment easily (Darnhofer et al., 2010a; Webb, 2013). Being open to accepting changes as good options is an ability to understand strategy as an unfolding process that helps decision-makers to implement emergent strategies (Darnhofer et al., 2010a). To be open-

minded is to be aware and to acknowledge the possibility that one can be wrong in beliefs and thoughts (Riggs, 2010). Consequently, open-minded people do not hold firmly in their beliefs or thoughts (Adler, 2004) and they consider other alternatives or sources of information (Baehr, 2011). These people engage with others and interchange ideas that promote learning (Rogers et al., 2013). Therefore, open-minded people are respectful of the opinions of others; are open to opposing positions coming out of a discussion; and consider the opportunities of learning from others (Adler, 2004; Riggs, 2010; Rogers et al., 2013).

2.5.2.4 Social capital aspects

Social capital can be explored through different aspects related to the connections of the farm business's main decision-maker. To consider social capital influencing the decision-making process, it is recommended to think about the multi-dimensions of social capital (Jansen et al., 2013). Looking into the literature, these aspects are conceptualised in the structure of relations between individuals or decision-makers and among them (Coleman, 1988). The notion of social capital was introduced by Lin (2001) as an investment in social relations with expected returns that provides three main kinds of profits: 1) the flow of information that provides useful information about available opportunities, 2) the value of different people that influence decision-making, and 3) social credentials or involvement in the community that provides access to resources through social networks and relations. Also, two complementary uses of the social capital concept have been introduced later: 1) social contacts shaped by trust, and 2) civic engagement (Putnam, 2000). Both social contacts that include communication patterns and civic engagement that includes the involvement in the community have been gradually affected by the Internet and new ways of virtual connections (Quan-Haase & Wellman, 2004). Social capital enables people to have more productive and more efficient ways of pursuing their objectives (Putnam, 1995, 2000). Since people decide, drawing on their experience and variety of social ties to form their judgments of the situation, it influences the decision-making process for people (Wiesinger, 2007). Moreover, three types of social capital have been introduced in the literature considering the strength of ties between individuals (Coleman, 1988; Granovetter, 1973; Lin, 2001; Szreter & Woolcock, 2004): bonding, bridging, and linking social capital.

Bonding refers to trusting and co-operative relationships with strong ties, amongst a small network of members who are similar in terms of their shared social identity such as age, socio-economic status, race/ethnicity, and education (Hawkins & Maurer, 2010; Putnam, 2000). This type of social capital is connected to the concept of closed networks (Coleman, 1988). The nature of a network in bonding provides stronger trust, generally informal collaboration, and long-term reciprocity (Cofré-Bravo et al., 2019; Lin, 1999). Examples of bonding typically include strong close relationships such as the relationships that family members, close friends, and neighbours have (Claridge, 2018). Strong close relationships depend on the individuals or groups and their goals (Woolcock & Narayan, 2000). For instance, neighbours have bonding when neighbourhood stability is a goal for them to achieve (Temkin & Rohe, 1998). Another example, poor entrepreneurs mostly depend on their immediate neighbours and friends (Woolcock & Narayan, 2000). It is seen that bonding provides a vital source of support to people when they face socio-economic or other kind of hardship since it relates to high level of trust (Burt, 2017; Claridge, 2018; Lin, 2001). However, bonding is not enough since individuals and groups need a wider range of network to connect to the world via weaker ties including bridging and linking (King et al., 2019; Putnam, 2000).

Bridging refers to relations between people who are dissimilar in social identity with weaker ties for collaboration characterised by larger and looser networks (Hawkins & Maurer, 2010; Szreter & Woolcock, 2004). This connection is within social groups when people feel a sense of shared identity and belongings (Claridge, 2018). Bridging provides access to resources and information shared between similar groups with common interests or goals (King et al., 2019; Klerkx & Proctor, 2013). Examples of bridging include people outside the immediate social connections such as employment-related people when the trust is weaker and may be more opportunistic (King et al., 2019; Pelling & High, 2005). Compared to bonding and bridging, linking refers to relations with weak ties that individuals build with dissimilar groups and individuals who have relative power over them (Hawkins & Maurer, 2010; Szreter & Woolcock, 2004). Linking is connected to the concept of open networks and allows the use of resources, ideas, and information from formal institutions such as banks and government agencies (Cofré-Bravo et al., 2019).

Regarding the sustainable livelihood framework (SLF), these three types of social capital can provide a household with access to emotional support, information and knowledge, and resources (Klerkx & Proctor, 2013). All three types of social capital are valuable for a resilient livelihood and having a balanced network helps to explore and exploit the opportunities of learning and development (Cofré-Bravo et al., 2019). Different valuable outcomes can be generated from different relationships ranging from the strongest ties, bonding, to the weakest ties, linking (Hawkins & Maurer, 2010; Lin, 2001). In this vein, Coleman (1988) stated that social capital can be at different scales, individuals, families, and groups. Also, Putnam (1995, 2000) mentioned that social capital is an inevitable part of social life in which an individual's life can be more productive by social connections. A productive life for individuals and families is defined by gaining benefits from the ties with others where communities provide benefits to individuals and families (Coleman, 1988). Social capital defines the extension of networks that are the credentials of individuals (Lin, 1999) and households (DFID, 1999) to others. Learning, innovation, and development is important part of sustainable livelihood that highlights the close relationship between social and human capital (DFID, 1999). Social capital in the farming systems has the same definition with the livelihood social capital in which the connections of farmers provide a range of support, influence knowledge flow, and lead to sustainable development with proper environmental outcomes (Burton et al., 2005; Lawal et al., 2009; Pretty & Ward, 2001).

2.5.3 Five capitals and decision-making frameworks together

Understanding adaptive capacity from a sustainable livelihood perspective provides valuable insights into how a business responds and adapts to disturbances relying on five capitals (Tanner et al., 2014). The SLF also highlights the role of individuals' capacity to respond to disturbances (Scoones, 2009; Tanner et al., 2014). In farming systems' adaptive capacity, the five-capitals framework can be utilised since the access to the capitals, trade-offs, the combination of capitals, and the relationship between capitals are important to apply in management practices. In this vein, Darnhofer (2014, p.549) stated the importance of relationship and link between the farming system's capitals for adaptive capacity: "it matters how the components are linked and the way in which the resources are used, not just the resources themselves". Generally, the five-capitals framework has been utilised to

measure adaptive capacity (Huai, 2016; R. Nelson et al., 2010; Nettle et al., 2018; Thapa et al., 2016). However, in studies of farming systems' adaptive capacity, the five-capitals framework does not conceptualise more detail on human and social capital (Nettle et al., 2018). Thus, expanding human capital and social capital in the farm management context can be considered to cover the attributes and aspects of these two capitals in adaptive capacity measurement, which brings decision-making within the measurement framework. The following section describes the subjective method of adaptive capacity measurement named perceived adaptive capacity.

2.5.4 Measuring perceived adaptive capacity

Considering subjectivity when it comes to measuring adaptive capacity, three main dimensions of adaptive capacity are introduced in the literature: risk perception (Grothmann & Patt, 2005; Jones & Tanner, 2015), perceived adaptation regarding the availability of five capitals that includes individual capabilities to mobilise resources (Grothmann & Patt, 2005; Jones & Tanner, 2015, 2017; Nettle et al., 2018; Thapa et al., 2016), and the management practices to address risk and uncertainty (Lockwood et al., 2015; Marshall et al., 2013; Nettle et al., 2018).

Firstly, uncertainty is central to the resilience concept (Walsh-Dilley & Wolford, 2015), since it is the unknown future that motivates people to be resilient either coping with the uncertain future or adapting to ongoing or upcoming disturbances (Jones & Tanner, 2017). Moreover, people form their decisions or intentions based on their relative risk perceptions before making an adaptive response to these disturbances (Grothmann & Patt, 2005). Hence, the first necessary component to make an adaptive response is risk perception, a cognitive process of risk appraisal, which is the main determinant of the motivation to adapt (Grothmann & Patt, 2005). Risk perception is an expression of the perceived probability of being exposed to the impact of change and disturbances (Rohrmann & Renn, 2000). This perception is important as Schwarzer (1992) stated that a minimum level of threat or concern must exist before people start contemplating the benefits of possible actions and thinking deeply about their competence to actually perform them. Therefore, adaptation assessment and response start after the risk perception process when people perceive at least a minimum level of threat (or opportunity), for example, the impact of climate change

(Grothmann & Patt, 2005). Risk and uncertainty perceptions are peoples' understanding of the environment and circumstances in that respective system (Grothmann & Patt, 2005). Furthermore, in the livelihood adaptation literature, the circumstances in which the household exists play an important role in taking livelihood strategies (DFID, 1999; Eakin & Bojórquez-Tapia, 2008). After perceiving risk and uncertainty (Grothmann & Patt, 2005), households utilise their existing capitals and adopt some strategies to achieve their livelihood goals (DFID, 1999). Thus, risk or uncertainty perception is the first factor that influences the measurement of perceived adaptive capacity.

Secondly, the ability to take adaptive responses is directly dependent on the availability and access to the capitals (Adger, 2003; Jacobs et al., 2015; Lemos et al., 2016). In addition, the decision-making approach, mostly seen in the climate adaptation literature, includes the ability of people to mobilise resources (Marshall et al., 2013). Based on the sustainable livelihood framework, resources are the five capitals (natural, physical, financial, human, and social capitals), which are key components of adaptive capacity (Huai, 2016; Lemos et al., 2016; R. Nelson et al., 2010; Shivakoti & Shrestha, 2005; Thapa et al., 2016). When it comes to considering subjectivity, people's understanding of their capabilities and capacities introduces the factors of the respective system that enables or constrains people to take an adaptive response or suitable strategy to achieve their goals (Grothmann & Patt, 2005; Jones & Tanner, 2015; Perrin et al., 2020b). The concept of adaptive capacity, as a part of the resilience literature, is developed in different areas such as personal resilience, psychological resilience, or livelihood resilience (Jones & Tanner, 2015). When people choose to take an adaptive response, their perception of their own adaptation is usually to some extent realistic (Grothmann & Patt, 2005). Moreover, the five-capitals framework, which has mostly applied to adaptation studies (Lemos et al., 2016; R. Nelson et al., 2010; Thapa et al., 2016), helps to understand the importance of capitals to assess adaptive capacity (Jacobs et al., 2015). The combination of the five-capitals framework (Jacobs et al., 2015) with the subjectivity of adaptive responses (Grothmann & Patt, 2005; Perrin et al., 2020b) highlights that people understand the influence of the five capitals on their ability to access, combine or apply these capitals to adapt to changes (Jacobs et al., 2015).

Finally, adaptive responses require adaptation strategies (Lemos et al., 2016). The definition by Lemos et al. (2016) describes that building adaptive capacity is firstly related to the

system's capitals; named generic adaptive capacity, and secondly is related to risk management; named specific adaptive capacity. Building adaptive capacity has been argued as a process including both generic and specific adaptive capacity (Lemos, 2008; Lemos et al., 2016; Tompkins et al., 2008). Also, it has been stated that the skills of management to address risk and uncertainty are embedded in the ability of resource mobilising (Marshall et al., 2013; Nettle et al., 2018). Regarding the specific circumstances of a system (like a household), different capitals play different functions in management strategies for addressing risk (Eakin & Bojórquez-Tapia, 2008). In this vein, adaptive capacity often focuses on the decision-makers and how they implement changes in the systems that they are involved in (Nettle et al., 2018). Therefore, for a decision-maker, pursuing different types of strategies, as well as understanding the advantages of particular strategies and combinations of capitals are of importance when they intend to build adaptive capacity (de Villiers et al., 2014; Eakin & Bojórquez-Tapia, 2008; Lemos et al., 2016). From the literature on livelihood adaptive capacity, risk management is an inseparable part of shaping adaptive capacity that empowers households (Lemos, 2008; Lemos et al., 2016; D. R. Nelson et al., 2009; Tompkins et al., 2008). Likewise, Lockwood et al. (2015) stated that perceived adaptive capacity is related to management approaches.

Combining adaptive capacity and subjectivity introduced the concept of "perceived adaptive capacity", where the farmer's perceptions of their adaptive capacity are to be measured. Measuring perceived adaptive capacity in this research considers the importance of the farmer's perceptions to manage undesirable and desirable disturbances. Because farmers' perceptions about their own capacity to manage shocks and stresses are of importance for their adaptive capacity (Béné et al., 2016b). It is mentioned that decisions are often, if not always, based on an individual's perceptions of reality, and not reality per se (Bandura, 1977; Béné et al., 2016b; Jackson, 2005). Therefore, with measuring perceived adaptive capacity, farmers' perceptions as the main decision-makers are taken to account. This measurement, also, assists industry agents or advisors to see the farmer's self-assessment of their adaptive capacity. There is a relationship between farmers' self-assessment of their management skills and their risk-taking attitude (Patrick, 2013; Shadbolt & Olubode-Awosola, 2013). Hence, with a high probability, there is a relationship between farmers'

self-assessment of their adaptive capacity (perceived adaptive capacity) and their real adaptive capacity.

Regarding the objectives of this research, New Zealand dairy farmers' choices in the way that they perceive uncertainty, the five capitals, and management practices influence the adaptive capacity of their farm business. These dimensions are to be considered in developing a tool to measure a New Zealand dairy farmer's perceived adaptive capacity.

2.6 Summary: a conceptual framework

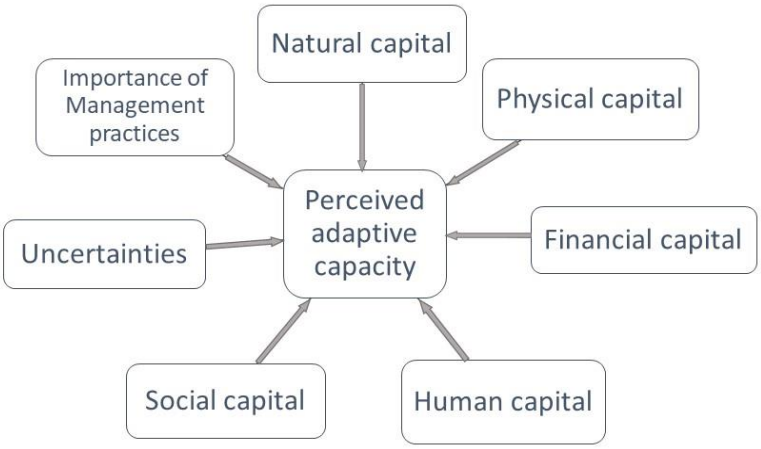
The literature review started with the resilience concept evolution, which originated from ecological systems and developed into social-ecological systems (SESs). To explore SES resilience, three attributes have been introduced in the literature; buffer, adaptive, and transformative capacity. Among these three attributes, adaptive capacity is of interest to the current study. Adaptive capacity is important in that it is the expansion of buffer capacity to endure more volatile situations while being prepared for transformation if required. Resilience across disciplines demonstrates that adaptive capacity has been important to a range of disciplines, such as farm management studies, where adaptive capacity helps to develop farming systems' resilience.

In addition, measuring adaptive capacity was explored to develop a conceptual framework to answer the questions of this study. The common frameworks to measure adaptive capacity in the literature were presented. This study sets out to develop a measure of the perceived adaptive capacity of New Zealand dairy farmers in the face of policy and economic volatility.

If we imagine a dairy farm like a tree, what is visible for us is its trunk, stem, and leaves. However, the main part of a tree is its roots with the primary function to support the performance. Every capital is a part of this tree. Natural and physical capitals make it possible to run a system. They are the most tangible part of a farming system. The financial capital is the most evident and historically recorded by farmers as a dairy farm operation. Then the decision-makers as human capital and their relationship with other people as social capital underpin the business and help it to survive facing uncertain environment by implementing management practices. The deeper the roots, the stronger the tree. In this

research, we tried to elicit an indication of whether the farmers have meant toward being adaptive. How they see the uncertainty in the environment, how they perceive their farming systems' capitals, and how important they see the management practices to cope with ongoing changes. These bring us to seven dimensions. Figure 2.5 demonstrates the conceptual framework proposed for this research in which seven dimensions including the five capitals, uncertainties, and management practices are proposed to assess and measure a dairy farmer's perceived adaptive capacity.

Figure 2.5: Conceptual framework- Perceptions of dimensions that lead to overall perceived adaptive capacity



The literature review revealed that the five-capitals framework has been a common framework to measure adaptive capacity for most studies. Moreover, the decision-making framework that emphasis human capital attributes and social capital aspects were considered. A mixture of the five-capitals framework and the decision-making framework was created. Also, subjective measurement was suitable to be adopted for measuring the perceived adaptive capacity.

In order to address each of the research questions, the adaptation of appropriate methods was required. The methods for this study were therefore selected with consideration of the research questions. The following chapter provides an explanation of the methods adopted, including a rationale for their selection and a description of how they were implemented.

Chapter 3 : Methods and data

3.1 Introduction

A research methodology is “the general approach the researcher takes in carrying out the research project” (Leedy & Ormrod, 2001, p.14). To conduct research, there are three common approaches: quantitative, qualitative, and mixed methods (Walliman, 2011). Since the research question is an implication of the perceived connection between theory and research (Bryman, 2004), this will shape the process of research and the methods that are necessary to conduct the research. For instance, a quantitative approach is suitable when numerical or statistical data is needed to answer the research question. In contrast, qualitative methodology is appropriate to answer questions requiring textural or open-ended data to develop a detailed form of actual experiments (Creswell & Poth, 2016; Walliman, 2011). In addition, when the research question is a relatively novel concept including quantitative and qualitative components, a mixed-method approach is suggested in the literature to provide a stronger understanding of the problem (Creswell & Poth, 2016; Johnson & Christensen, 2017). Since a mixed method has been chosen for this research, an overview of this approach is going to be described in this section.

3.2 Mixed methods approach

There is an age-old poem mentioned by Johnson and Christensen (2017) in their book of “Educational research; quantitative, qualitative, and mixed approaches.” This poem is by a Persian poet/philosopher ‘Rumi’ about an unknown creature in a dark room. Different people enter the room intending to discover the identity of the creature. Each person touches a different part of it, and so provides a completely different description. Only if they could all see together could they discover that the creature was an elephant. This is consistent with the definition of a mixed-methods approach as multiple ways of seeing the parts of the whole (Creswell & Clark, 2018). A mixed-methods approach is an approach involving both quantitative and qualitative data collection; and analysis to respond to the research questions (Creswell & Poth, 2016). The philosophy of mixed methods is ‘Pragmatism,’ which is determining what will work in practice for a particular situation (Johnson & Christensen, 2017). This philosophical position is an overarching worldview, with the focus on the consequence of research, associated with mixed methods research

(Creswell & Clark, 2018; Johnson & Christensen, 2017; Tashakkori & Teddlie, 2010). A researcher can choose the systematic combination or mixture of methods and procedures that work best for answering their particular research questions and needs to be decided upon prior to starting the research (Creswell & Clark, 2018; Johnson & Christensen, 2017; Johnson & Onwuegbuzie, 2004).

Decisions about mixed-method design are made focusing on answering the research question, and the time orientation of the approaches (Tashakkori & Teddlie, 2010). For instance, when the critical aspect of answering the research question is deductive and theoretical, it requires a quantitative-focused design with relevant qualitative data to enhance the study (Creswell & Clark, 2018; Johnson & Christensen, 2017; Tashakkori & Teddlie, 2010). The other aspect of designing a mixed-methods approach is a data-gathering sequence, which can be concurrent or sequential (Johnson & Christensen, 2017). Figure 3.1. shows different designs based on emphasis and the time orientation of phases.

Figure 3.1: Mixed methods design matrix

	Concurrent	Sequential
Equal Status	QUAL + QUAN	QUAL → QUAN QUAN → QUAL
Dominant Status	QUAL + quan QUAN + qual	QUAL → quan qual → QUAN QUAN → qual quan → QUAL

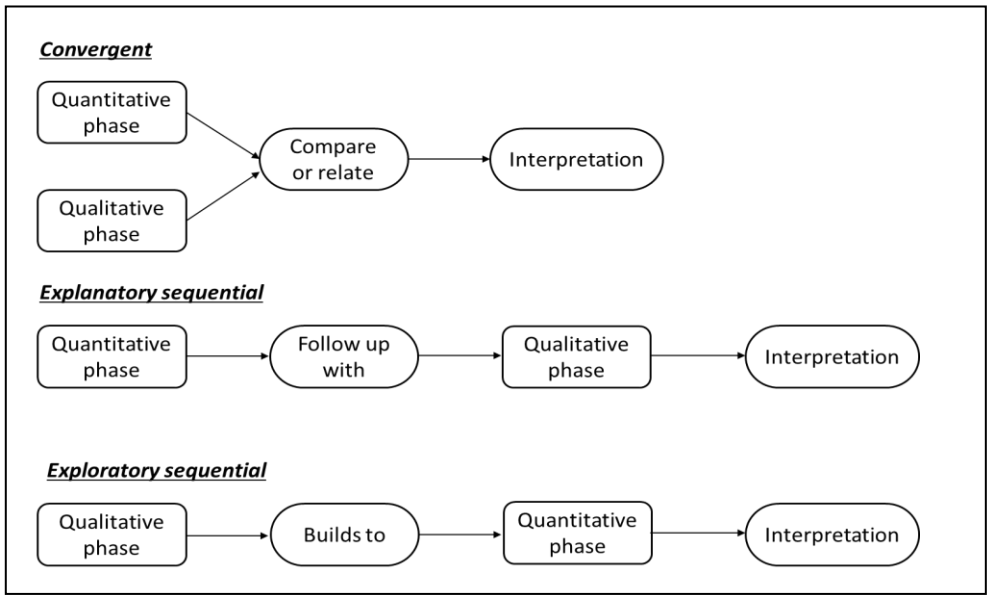
Uppercase letters show the phase dominance
(+) shows concurrency
(→) shows sequential

Source: Adapted from Johnson & Christensen (2017)

Status emphasis and time orientation provide nine designs; however, Creswell and Clark (2018) recommend three core mixed methods designs as useful frameworks for researchers. Firstly, the 'Convergent' design with concurrent phases brings the results of both quantitative and qualitative parts to be compared or to be combined. Secondly, the 'Explanatory sequential' design with the quantitative phase first followed by a qualitative section to explain or expand the first phase results. Finally, the 'Exploratory sequential'

design starts with qualitative data collection and analysis which is then used to develop a measuring instrument for the following quantitative stage. These three core mixed methods designs are presented below in Figure 3.2.

Figure 3.2: Three basic mixed methods designs



Source: adapted from Creswell and Clark (2018)

As Creswell and Clark (2018) stated; exploration through the qualitative phase is helpful when there is a lack of instruments and framework along with unknown variables. A qualitative investigation is needed to learn what variables, and theories will assist the researcher in answering the research questions (Creswell & Clark, 2018; Johnson & Christensen, 2017). Besides, a quantitative approach after qualitative phase can make the qualitative phase more acceptable by testing the generalisability of a theory to the broader population under investigation (Creswell et al., 2003). Since one of the goals for this research was developing instruments and a framework about unknown variables, an exploratory sequential mixed method has been adopted for this research.

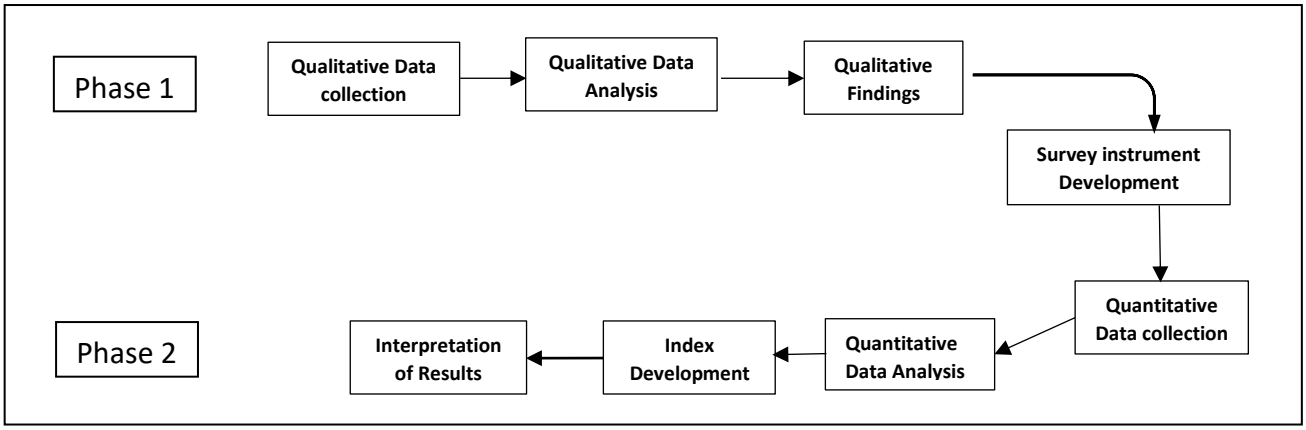
Resilience and adaptive capacity in dairy farming is a relatively new research concept. Also, little is known about the adaptive capacity of New Zealand dairy farmers. The lack of definition and framework makes it difficult to identify the dimensions of a dairy farmer's adaptive capacity when facing disturbances. Exploring the literature, the focus of this research is defined as "the perceived adaptive capacity of dairy farmers in New Zealand". In

this vein, the investigating framework includes uncertainty, management practices, and five capitals (human, social, physical, natural, financial) to address these key questions:

- What are the dimensions of the New Zealand dairy farmers' perceived adaptive capacity when facing external or internal pressures?
- Can an index be developed to measure a dairy farmer's perceived adaptive capacity?
- How do the dimensions affect the perceived adaptive capacity index?

Since measuring adaptive capacity is a challenge, undertaking a qualitative exploration helps to understand the dimensions of perceived adaptive capacity for dairy farming in New Zealand. The core concept of interest in this study was context-specific; thus, a qualitative approach using multiple case studies was helpful to collect information about dairy farmers' perceptions of current changes and their perceptions of managing the changes utilising the five capitals of their business. The information gathered from the case studies was used to aid the design of a suitable survey instrument. The subsequent quantitative phase was used to develop an index for dairy farmers' perceived adaptive capacity. Figure 3.3 illustrates the research design.

Figure 3.3: Visual diagram of the research design



3.3 Qualitative phase

The first step of the exploratory sequential mixed method is a qualitative phase that helps to provide an understanding of research participants' perceptions and actions in the context of their life and experiences related to the research question (Denzin & Lincoln, 2018; Ritchie et al., 2013). To undertake the qualitative phase, it is known that qualitative research

primarily relies on the collection and analysis of non-numerical data, such as words and pictures (Johnson & Christensen, 2017). Therefore, the researcher firstly needs to choose an appropriate qualitative approach including qualitative research techniques, sampling strategy, data collection, and data analysis.

3.3.1 Qualitative research techniques

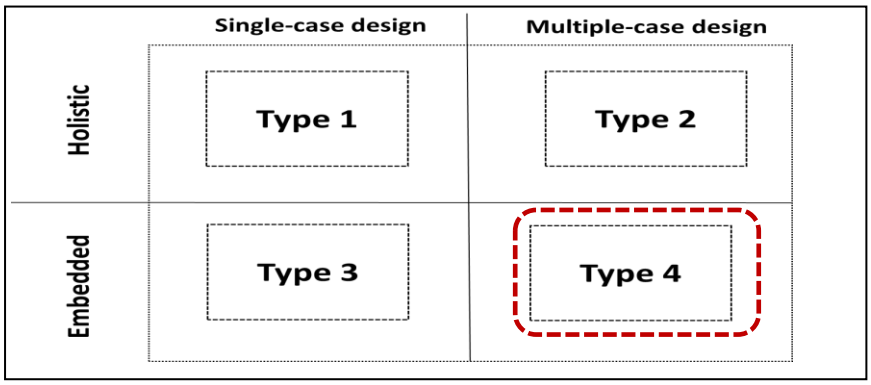
Five techniques were identified for qualitative research by (Creswell & Poth, 2016): narrative, phenomenological, grounded theory, ethnographic, and case study research. The narrative technique is the impulse to life story events into order and meaning. It can be in many forms, such as autobiography, life stories, personal stories, as well as biographies. Phenomenology focuses on the widest possible range of phenomena, gradually limiting the researcher's attention to particular phenomena. The grounded theory approach is a method for discovering theories, concepts, and hypotheses directly from data, instead of relying on *a priori* assumptions coming from other research or existing theoretical frameworks. Ethnography explores cultural phenomena from the viewpoint of the subject of the study and focuses on an entire cultural group. Case study research involves the study of an issue explored through one or more cases (Creswell & Poth, 2016).

The focus of understanding the issue or phenomenon with individuals in contextual conditions is the focus of this study, therefore the case study approach is the most appropriate technique (Creswell & Poth, 2016; Merriman & Tisdell, 2016; Yin, 2014). There are three variations of the case study approach (Stake, 1995): the instrumental single-case, the intrinsic case, and the collective or multiple-case study. The instrumental single-case and the intrinsic case are suitable when investigating one case in-depth (Creswell et al., 2007; Denzin & Lincoln, 2018). However, purposefully choosing a multiple-case study approach helps to show different perspectives on the same issue (Yin, 2003). Before choosing a multiple-case study technique, understanding the objective of the research is needed.

The case-study technique is helpful to understand a complex issue particularly when a large number of variables are to be investigated (Yin, 2003). The other aspect of utilising a case study is considering a unit of case study to understand the issue under investigation. It has been said that defining the ‘case’ as the unit of analysis is the first step in designing the case study approach (Yin, 2014). A unit can be an individual, multiple individuals, program, or

activity within the context, which is selected (Creswell et al., 2007). Based on the literature, two variants of case study design are identified: holistic and embedded case studies (Perry, 1998; Yin, 2014). A holistic case study considers the case as one unit, and focuses on the broad issues of the case as a whole, whereas, an embedded design explores some distinct units within the case individually (Yin, 2014). Figure 3.4 shows the four types of case study design. The type 4, embedded multiple-case was chosen for this research.

Figure 3.4: Four types of case study design



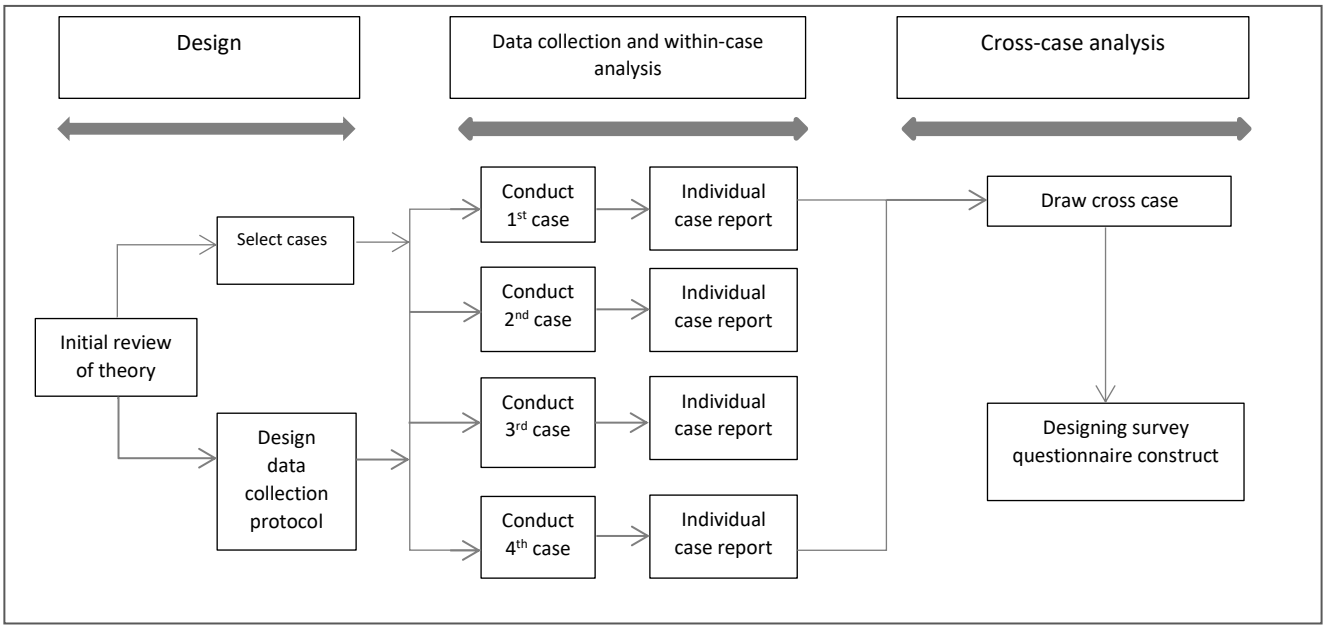
Source: Adapted from Yin (2014)

The focus of this research is identifying dimensions of dairy farmers' perceived adaptive capacity considering a new framework. Thus, the case study approach was chosen to develop a full understanding of the cases around the research intention. The primary aim of the qualitative phase was to investigate dairy farmers' perceptions of their business environment and management practices relying on the five capitals that they have in their farm business. Regarding changes such as shocks and growing stresses, their ability to effectively respond to these changes was investigated. Therefore, the qualitative phase sought to address these questions:

- What external and internal disturbances (shocks and stresses) the case farmers had experienced in the past 5 – 10 years and also those that they expected to encounter in the future?
- What are the case farmers' perceptions of how important the various capitals were for coping with the different shocks and stresses?
- Which management practices were implemented to cope with the disturbances?

Figure 3.5 provides an overview of the multiple-case study procedure in this research. To do this, an initial review of the literature was required to identify a framework of perceived adaptive capacity. This framework was an underpinning of the data collection protocol, which was tested in a pilot study and then modified.

Figure 3.5: Multiple-case study procedure diagram



Source: adapted from Yin (2014)

3.3.1.1 Sampling strategy and case selection

The sampling process used in qualitative research is not formulaic, in contrast; it depends on the researcher's decision of how many cases are needed to achieve the objectives of the qualitative research (Yin, 2014). A typical sampling method for qualitative research is purposeful (purposive) sampling (Creswell & Poth, 2016; Onwuegbuzie & Leech, 2007). This sampling strategy involves selecting cases relying on a specific purpose, not based on random selection (Collins et al., 2006; Dattalo, 2008; Teddlie & Tashakkori, 2003). Patton (1990) listed sixteen purposeful sampling strategies such as extreme case, typical case, and intensity case. Among the sixteen strategies, the intensity case is the case that is information-rich and is suitable to explore new concepts in the context while it is not extreme to demonstrate an unusual manifestation of a new concept (phenomenon). In addition to the sampling strategy type, for pure qualitative research, the sample size depends on reaching theoretical saturation, i.e. where no new data appears, and all theory concepts are well-developed (Birks & Mills, 2015; Guest et al., 2006). However, when the

mixed method is implemented, reaching saturation point is not the main aim of purposeful sampling. According to (Creswell, 2002), three to five participants is a reasonable sample size for a multiple-case study. In addition, 'availability' is an essential factor when choosing cases in purposeful sampling and cases can be randomly selected from information-rich cases (Dattalo, 2008; Robinson, 2014).

In this study, case selection criteria were based on theory, in which region, the size of dairy farm (Bouttes et al., 2019), and the dairy farmer's (main decision-makers) ownership (Pinochet-Chateau et al., 2005) were considered. The initial decision on sample size was three to five cases following a suggestion by Creswell (2002), for a multiple-case study. Regarding the purposeful sampling strategy for the qualitative phase, information-rich available farmers were chosen to interview. In this strategy, the next step was selecting cases by locating a convenient case that met the required criteria (Robinson, 2014; Robinson & Smith, 2010). The intensity case study was suitable for the sampling strategy, in which, the objective is choosing information-rich cases (Miles & Huberman, 1994). Four information-rich cases were selected based on the region that the farm business is situated, the size of the farming operation, and the ownership structure.

3.3.1.2 Data collection

Data collection for the case study can be from many sources including direct data or indirect data (Lopez & Whitehead, 2013). Indirect data are generated by external sources to the case, such as with documents or photographs reporting an event or an artistic rendition of an event or experience. However, direct data are generated from spoken or written words, and also observable body language, actions, and interactions (Lopez & Whitehead, 2013). Direct data collection is the most common technique in qualitative research and the main method for collecting data in a multiple-case study design is by interview (Eisenhardt & Graebner, 2007; Lopez & Whitehead, 2013; Yin, 2014). The interview method as a semi-structured format is the most appropriate one (Patton, 1990). The semi-structured format for an interview gives the opportunity of conducting an effective interview based on an unsolidified stream of questions while choosing the sequencing and the way in which questions will be asked (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Steenhuis & Bruijn, 2006; Yin, 2014). Therefore, the interview starts with broad and general warm-up questions

and is followed by more detailed open questions that should be tailored as necessary for each case (Adams, 2015). However, to manage time during the interview, some contextual data is needed before the interview to assist the researcher with the interview protocol and responses from the interviews (Creswell & Poth, 2016). To do this, completing a pre-interview questionnaire that collects demographic or background information from the cases beforehand will help to manage the interview (Horton et al., 2004).

Before heading to the interview, ethics requirements must be considered. Ethics requirements are relevant to researchers because ethical issues can occur in different phases of the research process (Hair et al., 2015). To avoid any ethical dilemma, the qualitative phase of the project was evaluated according to the Massey University Code of Ethical Conduct for Research. The project was evaluated to be low risk according to the Massey University Human Ethics Committee. Informed and voluntary consent to participate was obtained from the participants prior to any data being collected. An information sheet, consent form, and interview questions were provided to the farmers invited to participate in the project. Interviews were recorded with participant consent and transcribed by the chief researcher. The transcripts were sent to the participants for verification. Participants had the right to correct inaccurate information or choose to withdraw from the study at this stage. Confidentiality of the information was ensured at all times. The participants were also 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.

Each case farmer was contacted and briefed about the purpose of the study via email. After obtaining their preliminary response showing their interest in interview participation, a structured written questionnaire was sent to them via email to collect data about their socio-demographic characteristics, the farm's physical characteristics, the farmer's goals and management style, strategic thinking skills, perceived environmental uncertainty, the importance of management practices, and plans for upcoming stresses. A research information sheet and a consent (see Appendix 2) form were sent along with the questionnaire. The case farmers were asked to read the information sheet, sign and return the consent form, and answer the questions in the written questionnaire. The structured questionnaire was designed to assist the researcher in managing the interview time with fewer initial farm and farmer characteristic questions. Following their response to the

second email, the time and the place for the interview were organised. Then a semi-structured interview was conducted to collect data regarding the farmer's perception of the last 5-10 years' changes and their management practices utilising their five capitals. After data collection, data analysis is required.

3.3.1.3 Data analysis for the qualitative phase

The implementation of a comprehensive analysis procedure is very important in qualitative studies (Eisenhardt, 1989). However, there is no agreement about the systematic procedures for analysing such data (Houghton et al., 2015). Two types of analysis are used in multiple case study research (Creswell & Poth, 2016; Eisenhardt, 1989; Yin, 2014): 1) Within-case analysis which provides a detailed description of each case and themes within it, and 2) Cross-case analysis, which is carried out to analyse themes across the cases to identify similarities and differences.

The main aim of the within-case analysis is to become familiar with each case and to identify individual patterns within each case (Creswell & Poth, 2016). To do this, some procedures are needed such as describing, classifying, and connecting (Dey, 2003). The within-case analysis starts with reviewing interview transcripts from all cases to obtain an overview of responses (Ayres et al., 2003). Secondly, transcripts of each interview need to be investigated separately to identify significant statements, phrases, sentences, or paragraphs that could be classified with similar characteristics into the same group or category (Ayres et al., 2003; Baptiste, 2001). Examining each transcript is essential for finding patterns in, and eliciting themes from, data (Ayres et al., 2003; Houghton et al., 2015). Categories are built regarding related theory, research questions, and the researcher's role (Baptiste, 2001). The purpose of the pattern finding and theme drawing phase is to describe aspects of the phenomenon experienced by each participant regarding recent changes, mostly considered within the theoretical framework.

Cross-case analysis is the second level of analysis associated with a case study approach (Miles & Huberman, 1994). The cross-case analysis aims to seek patterns through a structured framework for similarities and differences between cases (Eisenhardt, 1989). Comparisons across the cases help to determine where similarities and differences exist (Yin, 1994, 2014). Comparing the experience of all cases is the purpose of the cross-case

analysis (Ayres et al., 2003; Miles & Huberman, 1994). The comparison between significant statements from each case helps to identify commonalities and differences between the cases (Stake, 2006).

3.3.2 Summary of qualitative data analysis

Since an exploratory sequential mixed method approach was used in this research, this brought the researcher to the implication of qualitative findings for the quantitative phase. Data analysis was conducted after each interview. The transcriptions were analysed for the within-case and cross-case analysis. Since the researcher was international and was not familiar with New Zealand dairy farming systems, case studies played a critical role for the researcher to gain an understanding of dairy farming in the New Zealand context. Following the within-case and cross-case analyses were designing a suitable survey instrument. Qualitative results are presented in Chapter 4 to provide more understanding of the dairy farming context in New Zealand within the dimensions of the perceived adaptive capacity for dairy farmers. Considering previous studies in New Zealand (Duranovich, 2015; Khatami, 2022; Pinochet-Chateau et al., 2005; Shadbolt et al., 2013), information gathered from this phase was used to design the context-related questions for the survey in the quantitative phase.

3.4 Quantitative phase

One of objectives for this research was developing a measurement tool to design a survey instrument. The results from the multiple-case studies and information from the literature were used to develop a survey instrument to collect the data required to achieve the objective of developing an index. Therefore, following the survey designed based on previous studies and the qualitative phase; the sampling strategy, data collection, and data analysis for the quantitative phase are described here.

3.4.1 Survey design

Designing questions for the survey was an important step in assessing or measuring the perceived adaptive capacity of a New Zealand dairy farmer. Based on the literature, looking at a decision-maker's perceived adaptive capacity has been introduced as a subjective assessment approach (Jones & Tanner, 2015; Nguyen & James, 2013). A survey instrument

was designed based on the surveys from previous studies in New Zealand and using the results of the multiple-case study. The new survey (see Appendix 4) mainly intended to capture the dairy farmers' perceptions of uncertainty, perceptions of the business's five capitals, and perceptions of management practices. The questions in the survey were organised into seven main sections:

1) Questions were asked with the objective of capturing demographic information about the farmer and the farm business.
2) Questions about goal and management style were asked with the objective of capturing the farmer's perceptions about their reliance on their five capitals in reaction to ongoing changes in the farm business.
3) Questions about farmer's attributes were asked with a specific focus on their human and social capitals
4) Questions about sources of information were asked with the objective of capturing other people's involvement when the farmer makes big decisions. These questions cover some aspects of social capital for the farm business.
5) Questions about regulation impact and planning were asked with the objective of capturing the farmer's human capital in more detail regarding upcoming changes in New Zealand dairy farming.
6) Questions about the farm business environment were asked with the objective of capturing the farmer's perceptions of uncertainty.
7) Questions about management response to change were asked with the objective of capturing the farmer's perceptions of management practices.

The first section of the survey obtained data on farmer demographics and farm business information. In the literature, socio-demographic characteristics include age, gender, education, marital status, household, employment, and income (Cohen et al., 2006; Rocha et al., 2002). Based on the research objectives, different socio-demographic variables are considered (Cohen et al., 2006). In this research, the dairy farmer's age, gender, education, farming experience, current main role, and business stage were included as the socio-demographic characteristics. Moreover, the farm characteristics such as the location of the farm business, animal stocking rate, milk production and so on, were asked. The responses

to the first section of the survey were used to identify any relationship between the perceived adaptive capacity index and farmer demographics or farm business information.

Among these seven sections, sections 1, 3,6, and 7 are most similar to the previous study by Duranovich (2015) who surveyed dairy farmers to capture the resilience attributes of New Zealand dairy farmers. Moreover, sections 6 and 7 are similar to the study by Shadbolt and Olubode-Awosola (2013) about New Zealand dairy farmers and risk. In addition, Khatami (2022) had similar questions to those in sections 1, 6, and 7 along with other questions to capture risk portfolios in New Zealand dairy farming. These previous studies helped to identify questions to capture demographic information, farmer attributes, perceptions of uncertainty, and management practices. Using previous surveys, the newly designed survey was extended to capture more information with respect to the farmers' perceptions of what they do facing disturbances. Adding more questions or modifying previous questions was based on the qualitative results about the farmer's perceptions of five capitals. For instance, Duranovich (2015) focused on the farmer's resilience attributes. In this vein, he asked three questions to capture 'willingness to accept change' as an aspect of those attributes in the survey. Accepting change as an attribute of human capital needs the willingness to make changes as the first step and also, for the farmers, it takes time to implement changes. However, based on the qualitative findings regarding the ongoing changes in the context of dairy farming in New Zealand, some more questions are needed to capture 'willingness to accept change'. Moreover, some modifications were required. Tables 3.1 and 3.2 are examples of the modification of questions from previous studies.

In addition, questions in sections 2, 4, and 5 were designed based on literature review and qualitative findings to capture more detail of the farmer's perceptions of five capitals in the farm business. For instance, to capture the farmer's perceptions of the natural capital of their business, there are six questions in section 2. Table 3.3 shows this example.

Table 3.1: An example of questions from a previous survey in New Zealand

I intend to make time to implement changes required in my farm business.
I am willing to make changes to my farm business.
I am willing to face uncertainty in my business.

Source: Duranovich (2015)

Table 3.2: An example of added and modified questions of the newly designed survey (human capital) used in the current study

I am aware that there will always be regulation yet to come in
I think gaining consents will be tougher when in the future we wish to renew current consents
I know the stocking rate is going to come under more scrutiny
I intend to make time to implement changes required in my farm business.
I have thought about changing my land use if environmental issues prevent us from continuing to run a dairy operation
I have thought about exiting the dairy industry if environmental issues prevent us from continuing

Table 3.3: An example of added questions of the newly designed survey (natural capital) used in the current study

I aim to minimise the use of agricultural chemicals on the farm to protect the environment.
I have tried to consider our business's environmental footprint of our business and improve it to prevent future environmental costs.
I know sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.
I am willing to accept land-conserving costs besides my operation costs
Improving environmental footprint has imposed some costs on our business
I aim to diversify my assets by having on-farm and off-farm investments

The following sections describe the questions of seven identified dimensions in the conceptual framework for developing perceived adaptive capacity index.

3.4.1.1 Uncertainty

The first focus of the survey was to provide statements to elicit farmers' perceptions around the changing environment that may affect their farm business over the next five years. The statements focused on five different sources of uncertainties: production-related, market-related, regulatory, financial-related, and human resource-related uncertainties. Exploring responses to a set of uncertainties helped to establish the farmer's perceptions. According

to the literature, uncertainties will affect their perceived adaptive capacity (Grothmann & Patt, 2005; Jones & Tanner, 2015). Any uncertainty can create opportunity or threat (Folke, 2006) as perceived by a dairy farmer. Both 'opportunity' and 'threat' options indicate a high level of perceived uncertainty (so is allocated a score of 5 by the researcher) while the other option in the survey is 'opportunity & threat', which shows a moderate level of perceived uncertainty (allocated a score of 3). These options demonstrate how a farmer perceives each uncertainty, as a high or a moderate change. The perceptions of a relatively large change show the farmer's awareness of that change is either an opportunity or a threat.

Also, investigated, was the farmer's expectation around the rate of change for each uncertainty in the coming five years. Farmers were asked to register their responses using a Likert scale, to ascertain how they rated the pace of change for possible uncertainties, ranging from 'decreasing rapidly', 'decreasing slowly', 'constant' to 'increasing slowly' and 'increasing rapidly'[5]. The other dimension investigated was the farmer's perceptions of the likelihood of that uncertainty presenting within the next five years. Again, farmers were asked to register their response, using a Likert scale ranging from 'rare', 'unlikely', 'possible' to 'likely', and 'almost certain'[6] of the likelihood of the uncertainty happening.

The combination of these three dimensions of the uncertainties (that is, opportunity/ threat plus the expectation regarding the rate of change plus the likelihood of the uncertainty becoming a reality) shows the farmer's overall perceptions of different uncertainties. For example, when a farmer perceives a source of uncertainty as a 'threat' and they expect the rate of change to be decreasing slowly, and they rate the probability of occurrence as 'almost certain'; this combination has a simple mean of ($\frac{(5+2+5)}{3}$), which equals 4. Another farmer may identify a source of uncertainty as an opportunity, they expect the rate of change to be 'increasing slowly' with a possibility of occurring 'possible'. This will likely have a simple mean of ($\frac{(5+4+3)}{3}$), which also equals 4. This score will be recorded as the three-dimensional impact of the uncertainty. These examples are shown in Table 3.4.

[5] Decreasing rapidly=1, decreasing slowly=2, constant=3, increasing slowly=4, increasing rapidly=5
[6] Rare=1, unlikely=2, possible=3, likely=4, almost certain=5

Table 3.4: An example of farmers' perceptions of the likelihood of an uncertainty

Source of uncertainty (Climate variation)	**Opportunity**	**Threat**	**Opportunity & Threat**	**Level of uncertainty**					**The likelihood of happening**				
				Decreasing rapidly	**Decreasing slowly**	**Constant**	**Increasing slowly**	**Increasing rapidly**	**Rare**	**Unlikely**	**Possible**	**Likely**	**Almost certain**
Farmer 1		●			●								●
Farmer 2	●						●				●		

3.4.1.2 Management practices

The second focus of the survey was to provide statements to elicit farmers' perceptions around a number of recognised practices for managing farms such as on-farm, marketing, financial, and human-related management practices. For each method, farmers were asked to indicate whether they use this practice on their farms or not. The other part of the question was around their perception of the importance of each management practice. Exploring their responses reveals the farmer's perceptions about the management methods that they follow. According to the literature, the farmer's perceptions of their management practices will affect their perceived adaptive capacity (Lemos et al., 2016; Tompkins et al., 2008). Thus the perceptions of management practices are part of addressing uncertainty and developing perceived adaptive capacity.

3.4.1.3 Five capitals

A third component of the survey was focused on the five capitals of the farm business: natural, physical, financial, human, and social capital. To address each capital, statements were presented to elicit farmers' perceptions of the capitals of their own farm business, particularly when they face new situations. All the statements related to the five capitals can be found in different sections of the survey, including goal and management, farmer's attributes, source of information, and regulation impact and planning (see online survey at Appendix 3).

Impacts on a farm's natural capital can come about through external forces, such as drought, flooding, and earthquakes, etc. The focus here is on the importance of their natural

capital and attitudes and perceptions needed for sustainable dairy farming and to conserve the natural capital. Therefore, the statements were presented to investigate the farmers' perceptions on the extent to which they agree with natural capital conservation using different methods such as minimising the use of agricultural chemicals or accepting the conservation cost.

Physical capital includes the items that help better utilising natural resources in the production process (Uphoff, 2012). Both human-made material resources (like irrigation, tools, and equipment) and physical items (like pasture, and livestock) were considered as physical capital. Investments in physical assets that support increases in land, tools, livestock, etc improve the effectiveness of physical capital (Berti et al., 2004). The statements related to physical capital were designed to elicit farmer's viewpoint of the importance of the livestock, pasture, and infrastructure of the farm business. Also, the farmer's perceptions on their working to improve items related to physical capital.

Perceptions about financial capital were a subjective way of expressing the farmer's holistic long-term financial state. Statements presented in the survey allowed the farmers to indicate both their current and future aims regarding their financial capital. Current financial aims have been expressed in terms of profit maximisation or financial prosperity being the key goal & primary reason for operating the business since their business is mostly driven by financial profits as a motivation. Also, the farmer's perceptions about passing the farm on to children or selling it for a reasonable price demonstrated their long-term decision on their financial capital.

Human capital is directly related to the farmer. It was investigated through different attributes of human capital in accordance with the literature (Duranovich, 2015; McCann et al., 2009; Price & Leviston, 2014; Rogers et al., 2013). Seven attributes were identified for the farmer as the main decision-maker. These seven attributes are: 1) background; 2) locus of control; 3) self-efficacy; 4) sense-making; 5) strategic thinking; 6) willingness to accept change; and 7) open-mindedness. For each of these, a number of statements were presented to which the farmers would respond.

Social capital is related to the person's relationship with others (Coleman, 1988; Putnam, 1995). It was investigated through different aspects of social capital following the literature (Bourdieu, 1986; Burt, 2000; Lin, 2001; Putnam, 2000). Six aspects were identified for farmer's social capital: 1) value of trustworthy people; 2) source of information; 3) involvement in the community; 4) bonding; 5) bridging; 6) linking. For each of these aspects, some statements were presented to which the farmers could respond.

All survey questions and their coding variables used for data analysis are presented in the quantitative results, Chapter 5 . The statements used five-point Likert scales, where the respondents were asked to express the importance of each statement to them, by using the scale. These Likert-scale series of questions were combined into a single composite score during the data analysis process (Boone & Boone, 2012). To ensure the survey statements and response categories were clear and unambiguous, a pilot survey is necessary (DeVellis, 2016). A pilot survey was conducted with seven New Zealand dairy farm decision-makers. Their feedback regarding the online survey was used to finalise the survey.

3.4.2 Sampling strategy for the quantitative phase

Generally, random sampling in quantitative studies aims to ensure the collection of data that reflects the characteristics of the population of interest (Hair et al., 2015). Determining the sample size within an experimental design is one of the inter-related features of research that can influence the detection of significant differences, relationships, or interactions (Bartlett et al., 2001; Peers, 1996). The researcher chooses a sample design by finding out the best sampling approach for the study to minimise sampling process error (Hair et al., 2015; Scheaffer et al., 2012).

Cochran's (1977) formula for the sample size for both continuous and categorical data is the method used most often in the literature (Bartlett et al., 2001). Using Cochran's (1977) formula, a good sample size depends on three criteria: the level of confidence or risk (the alpha (α) level), the level of precision, and the degree of variability in the attributes being measured. First, α level, the acceptable margin of error (Type I error) often is chosen from 0.10, 0.05, or 0.01, to determine the appropriate sample size (Ary et al., 2018). This is the confidence interval, also known as risk or error means. For example, if $\alpha = 0.05$ or a 95% confidence level is selected, means that 95 out of 100 samples will have the true population

value within the range of precision specified (Scheaffer et al., 2012; Singh & Masuku, 2014). The key idea for the α level is the Central Limit theorem[7], with the normal distribution assumption for the mean. However, there is a serious concern about the detection of non-normality in Likert-type data (Schoder et al., 2006). To address this concern, it has been shown that parametric statistics can still be utilised for Likert scales assuming non-normality (Norman, 2010).

Second, the level of precision, known as sampling error or acceptable margin of error, often expressed in percentage (e.g., $\pm 10\%$) mentions the range in which the true value of the population is estimated to be. The acceptable margin of error in Cochran's formula is the percentage of Type I error that a researcher is willing to accept (Cochran, 1977). For example, when it is found that 70% of respondents in the sample have done a recommended practice, with a precision level of $\pm 7\%$ the researcher can conclude that between 63% and 77% of respondents in the population have done the practice (Singh & Masuku, 2014). The level of precision can be chosen from $\pm 3\%$, $\pm 5\%$, $\pm 7\%$, or $\pm 10\%$, the lower value shows/generates a higher degree of precision (Bartlett et al., 2001)

Third, the degree of variability refers to the distribution of attributes in the population. This variability indicates the structure of the population (Bartlett et al., 2001). A small sample size is required for the homogenous population while a large sample size is required for the heterogeneous population (Singh & Masuku, 2014). Since the degree of variability of the population is not easy to identify, the researcher needs to estimate the variance of variables either scaled or categorical variables (Bartlett et al., 2001). For a scaled variable such as the Likert scale (seven-point or five-point), the researcher should determine the inclusive range of scale and the standard deviations that include all possible values in the range (Bartlett et al., 2001). Below is the explanation of the sample size for a five-point scale with chosen α level, precision level, and estimated variance.

[7] Central Limit Theorem says when a population is repeatedly sampled, the average value of the attribute obtained by those samples is equal to the true population value (Kwak & Kim, 2017; Yamane, 1967).

The five-point scale gives four standard deviations, two on either side of the midpoint which is assumed to be the mean (Bartlett et al., 2001). The variance estimation of the five-point scale is:

$$S = \frac{5(number\ of\ points\ on\ the\ scale)}{4(number\ of\ standard\ deviation)} = 1.25 \qquad (3.1)$$

S is used in Cochran's (1977) sample size (n_0) for continuous data:

$$n_0 = \frac{t^2 * S^2}{d^2} \qquad (3.2)$$

Where $t = 1.96$, the t-value for $\alpha = 0.05$ (Student's t distribution), and d is an acceptable margin of error for the mean or the precision level.

A review of mail surveys showed that for research involving small businesses the average response rate was only 27% (Bartholomew & Smith, 2006). Since survey data collection relies on the voluntary participation of respondents and a low response rate is common with a mailed questionnaire (Bartlett et al., 2001; Cochran, 1977; Scheaffer et al., 2012), choosing a lower precision level targets a smaller sample size to meet the common response rate. Assume that the precision level has been set at $\pm 7\%$, so d is estimated by multiplying the number of points on the primary scale (five-point scale) with the chosen precision level (7%), so:

$$d = (5 * 0.07) = 0.35 \qquad (3.3)$$

Therefore, the sample size for a study using a five-point scale with:

$\alpha = 0.05$, $d = 0.35$, and $S = 1.25$ is

$$n_0 = \frac{(1.96)^2 * (1.25)^2}{(0.35)^2} = 49$$

This sample size can be adjusted, if the number exceeds 5% of the population (N) (Cochran, 1977). The adjusted sample size (n_1) comes from this formula:

$$n_1 = \frac{n_0}{1 + \frac{n_0}{N}} \qquad (3.4)$$

With a population size of 8,788 dairy farmers including 6,940 owner-operators and 1,848 herd owner sharemilkers (DairyNZ, 2019) a target sample size of 49 does not exceed 5% of the population (439), therefore, using the adjusting formula (formula 3.4) was not required. In addition to the target sample size, the low response rate problem was considered. The survey was conducted online via an internet link utilising the Qualtrics survey software. To reach the target sample size, a list of 209 emails from an industry database was sent out. A page was designed as a description on the pre-survey page that gave an opportunity to the farmers to decide whether they want to continue responding or not. This page complied with the voluntary participation of respondents mentioned by Bartlett et al. (2001) and Scheaffer et al. (2012). Being volunteered via response to the questions increased the chance of reaching back from them. From a total of 209 surveys, 106 responses (51%) were received, of which 65 (31%) were useable for the data analysis. This rate was above the average response rate of 27% for research involving small businesses mentioned by Bartholomew and Smith (2006). After collecting survey data, quantitative data analysis was required. The methods for this analysis are described in the next section.

3.4.3 Data analysis for the quantitative phase

Data analysis for survey data starts with vetting for consistency and completeness of the questionnaire (Kitchenham & Pfleeger, 2003). The existence of any pattern of non-response questions must be investigated to avoid any systematic bias (Heeringa et al., 2017). In the case of missing values issues, there are different ways of imputing values for the missing data or omitting the respondent from further data analysis (Little & Rubin, 2002). However, when the amount of missing data is excessive and/or the values are categorical rather than numerical, imputing values does not work (Kitchenham & Pfleeger, 2003). After addressing missing data, data are coded by converting nominal and ordinal scale data into numerical data (Chambers & Skinner, 2003; Kitchenham & Pfleeger, 2003).

Following a descriptive analysis of the data, which demonstrates some interpretation, the next step starts with choosing a weighting method to reduce dataset dimensions and create

scores for several pre-defined dimensions of data to be used in the index development. There are three approaches to weighting in the literature (Booysen, 2002; OECD, 2008; Pomerol & Barba-Romero, 2012). First, subjective weighting is determined by the subjective judgments of experts. Second, mathematical weighting relies on mathematical manipulation of data, such as Principal Component Analysis (PCA), factor analysis, or regression analysis. Third, Equal Weighting (EW) assigns the same weight to variables or indicators (Jiang & Shen, 2013). Among these approaches, two popular weighting methods are considered: the PCA and the EW (Jiang & Shen, 2013; Monterroso et al., 2014; R. Nelson et al., 2010)

Originally, PCA was used to reduce multidimensional data into several main components without much loss of information (Field, 2013; Hair et al., 1998). However, it has been used by scholars to construct composite indices to quantify a multidimensional concept, and common practice has been to use the first component since it accounts for the largest variance of data (Jiang & Shen, 2013; Monterroso et al., 2014). Equal Weighting is a widespread approach and its underlying assumption is that each variable is interrelated and equally bounded by the other variables (Huggins, 2000).

Through the two weighting methods, the survey statements (variables) related to each dimension, create a score for each dimension that will be used when creating an index. The score from the PCA is the first component as a weighted linear combination of a set of variables (Field, 2013; Jolliffe, 2011). This method is explained in Section 3.4.3.1. Also, the EW of the survey statements (variables) creates a different score for each dimension and is explained in Section 3.4.3.2. The next step in the quantitative analysis is to use the Analytical Hierarchy Process (AHP), a multi-criteria decision-making tool to find out the relative importance of the different pre-defined criteria. The AHP method is explained in Section 3.4.3.3. Finally, the relative importance achieved from the AHP is going to be utilised to develop an index for two calculated scores from two weighting methods.

3.4.3.1 Principal component analysis weighting

Based on the survey design, there are a large set of statements that need to be reduced for further analysis. A principal component (PC) is a latent variable or composite descriptive of the information contained in the measured variables, which includes the causal flow from the variables to the component. The PCA explains the maximum amount of total variance by

transforming the set of variables into a linear combination (Field, 2013; Jolliffe, 2011; Meyers et al., 2016; Williams et al., 2010). Thus, the components are weighted linear combinations of the variables. Applying PCA includes identifying a suitable sample size, dealing with missing data, and calculating the scores for the first principal component.

a) The sample size for conducting PCA

The first step of the PCA technique is to consider the sample size (de Winter et al., 2009). There are some guiding conditions cited in the literature like 'the Sample (N) to Variable (p) ratio (N:p)' to determine adequate sample size (Hogarty et al., 2005). The N:p ratio refers to the number of participants (N) and the number of variables (p), where such a ratio is usually acceptable between 3:1 and 15:1 (Abdi & Williams, 2010; Williams et al., 2010). Although applying PCA to small sample sizes is treated with caution, there are varying opinions around this subject (de Winter et al., 2009; Williams et al., 2010). According to MacCallum et al. (1999), concerning the complex dynamics of PCA, some conditions help apply PCA to small samples. For instance, MacCallum et al. (1999) and de Winter et al. (2009) indicated that high communalities between variables allow the sample size to be relatively small. Communality is the extent to which an item (variable) correlates with all other items (Tabachnick & Fidell, 2012). If communality is low (between 0.0 and 0.4), then that variable may struggle to load significantly on any component; however, a communality higher than 0.6 to 0.9 is suitable (Field, 2013). Also, a suitable sample size can be tested using the correlation matrix, the Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy, and Bartlett's Test of Sphericity (Field, 2013; Williams et al., 2010). The KMO measurement lies between 0 and 1, and a dataset with a KMO > 0.50 can be considered suitable for PCA as long as Bartlett's Test of Sphericity is significant ($p < 0.05$) (Field, 2013).

Two things are considered when conducting a PCA; the correlation between the variables, and the number of selected components. First, before executing a PCA, a correlation between the variables can be checked through the correlation matrix. If any of the correlations are too high (say above 0.9), it means the two variables seem to be measuring the same thing. Therefore, it is necessary to remove one of the variables from the analysis. The other alternative is combining the variables in some way (for example, by taking the average) (Jolliffe, 2011). Second, utilising a PCA as a dimension reduction of variables

requires using an approach to choose how many components are acceptable for a set of data. The classic technique of Kaiser's criteria takes those components with eigenvalues[8] greater than unity (Yeomans & Golder, 1982). Although a crude method based on an eigenvalue ≥ 1 is often used as an approach to defining the number of components (Minka, 2001), when PCA is used as a weighting method, the common way is choosing the first component which accounts for the largest amount of total variation in the data (Jiang & Shen, 2013).

b) Dealing with missing data before PCA

Applying a PCA requires a complete set of data, having dealt with any missing data (Jolliffe, 2011; Meyers et al., 2016). Since respondents could leave any question unanswered, there are often missing values in the dataset. There are two ways to deal with this problem: list-wise and pair-wise deletion (Field, 2013; Meyers et al., 2016). In list-wise deletion, a case is excluded from analysis because it has a missing value in at least one of the specified variables. However, in pair-wise deletion, a case is excluded only from the calculations for which data is missing (Field, 2013). To avoid omitting information, if a high proportion of observations contain missing values, Tabachnick & Fidell (2012) advised against excluding a case when the missing data is non-normally distributed or the sample size is too small after exclusion. Missing data with no specific pattern scattered randomly across variables and cases is not a serious problem. The example of non-random missing data is where the same questions in the questionnaire are repeatedly left unanswered. For small sample sizes, the pair-wise deletion method was recommended for handling the missing data to avoid the cases being deleted (Tabachnick & Fidell, 2012).

c) Calculating PCA score for further analysis

One of the potential useful outcomes of PCA is the component scores (Tabachnick & Fidell, 2012). The first PC, a weighted linear combination of the variables is computed. Each participant's score is computed by multiplying the original variable score (on the five-point

[8] The core of component analysis (PCA) is built on the concept of Eigenvectors and Eigenvalues. An eigenvalue is a number that shows how much variance there is in the data in the direction. The eigenvector with the highest eigenvalue is therefore the principal component (Field, 2013; Weingessel & Hornik, 2000).

scale) by its component coefficient (weight) and then summing the values. This process gives a single value for the PC of each case (Meyers et al., 2016) and can be written:

$$PC_i Score = \sum_{p=1}^{n} Coefficient_p \times variable_p \qquad (3.5)$$

$$i = 1, \dots, N \qquad \text{and} \qquad p = 1, \dots, n$$

Where i represents each participant and p represent each variable.

The first component accounts for the largest amount of total variation in the data; the second, for the second-largest amount of total variance, and so on (Jolliffe, 2011). As a weighting method, the first component, which accounts for the largest amount of total variation in the data is the component needed here.

3.4.3.2 Equal weighting

Equal weighting of variables has been generally accepted in numerical taxonomy and has been actively advocated (Adams, 1975). This method assigns the same weight to components, variables, or categories (Huggins, 2000; Monterroso et al., 2014; Rigby et al., 2001). To do equal weighting, the variables for dimensions are treated equally. So, the mathematical form of the EW score can be written, where n is the number of variables, i and p are as defined previously:

$$EW_i Score = \frac{\sum_{p=1}^{n} variable_p}{n} \qquad (3.6)$$

3.4.3.3 Analytic Hierarchy Process

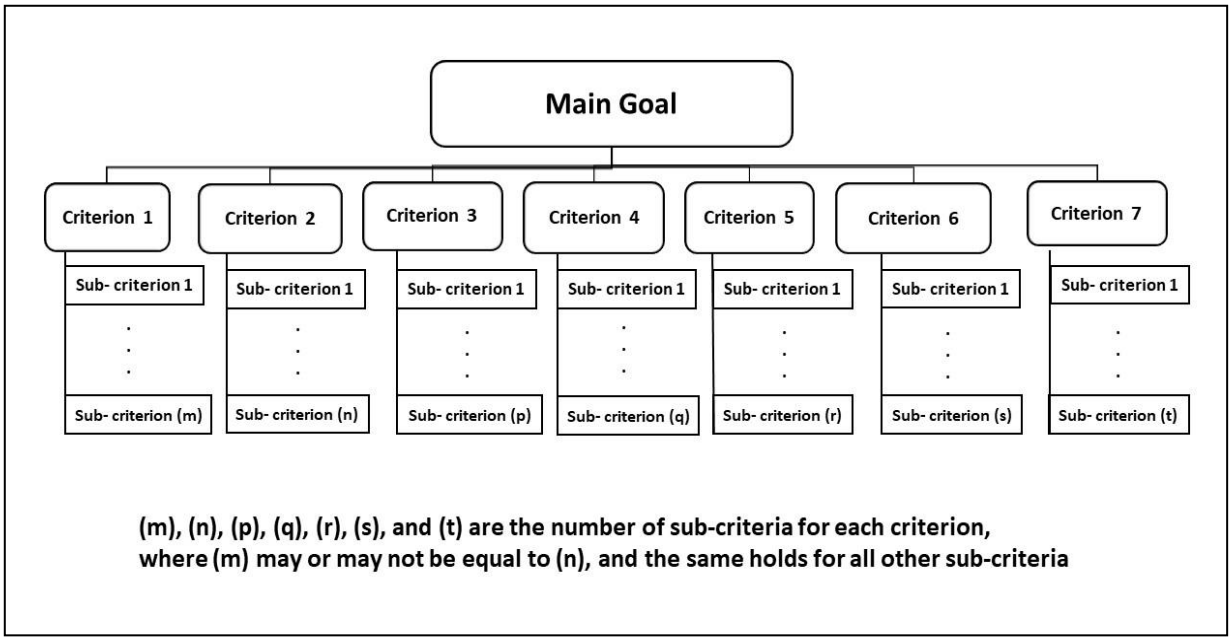
The Analytic Hierarchy Process (AHP) has been used as a Multi-Criteria Decision Making tool (Agha et al., 2012; Saaty, 1980) since Saaty (1980) proposed the method. This approach decomposes and synthesises a complex problem or object, often containing a great deal of uncertainty, to a set of simple to measure objectives or goals (Saaty, 1980), such complex problems are common in economic, social, and management science. Saaty (2008, p 84) suggested that when making a decision, it is necessary to see the problem from different

perspectives to understand the need and the purpose of the decision, alongside the criteria of the decision. In AHP, it is necessary to consider the entire problem before making a decision (Shapira & Goldenberg, 2005). The main characteristic of the method is the weighting of different factors introduced as criteria and sub-criteria (Shapira & Simcha, 2009). Therefore, this method provides an instrument for the selection of multiple criteria, and the derivation of their weights (Saaty, 1980; Shapira & Goldenberg, 2005; Shapira & Simcha, 2009). To cope with the complexity of the problem, the AHP approach uses two stages: hierarchy construction; and pairwise comparison (Saaty, 1990).

Firstly, the primary and secondary goals are organised into criteria and sub-criteria in a hierarchy-type structure, reflecting their mutual relationship. Sub-criteria or secondary goals are the attributes contributing to achieving the primary goal (Shapira & Simcha, 2009). Therefore, arranging the important factors for deciding on a hierarchic structure from an overall goal to criteria, sub-criteria, and alternatives is the most critical phase (Saaty, 1990). The number of criteria or sub-criteria in each level of the hierarchy is limited to seven (Saaty, 2001). This limitation originates from the human ability to discriminate, known as a psychological limit of 7 ± 2 (Saaty, 1980). This psychological limit is a way to avoid inconsistency (Saaty & Vargas, 2012). It suggests that $7 + 2$ items to compare simultaneously leads to a 9-point scale to distinguish the differences, which is the highest finite range of scale to have consistent judgment in the AHP method (Saaty, 1980; Saaty & Vargas, 2012).

Secondly, after mapping the interrelationships between different factors, it is necessary to compare them in a pairwise manner. This comparison will show which attribute or factor in the level has a greater influence on the hierarchic level (Saaty, 1980, 2008; Shapira & Simcha, 2009). Figure 3.6 presents a general form of AHP.

Figure 3.6: General hierarchy form for AHP



Source: Adopted from Saaty and Vargas (1982)

AHP is a comparison, based on the relative scale of priorities (Saaty, 1980). To make comparisons, a fundamental 1-9 scale of numbers has been suggested that use the ratio of absolute numbers to calculate weights (Saaty, 1990, 2008, 2013). The fundamental scale of AHP is shown in Table 3.5. The comparison values taken from this scale are used to derive a relative scale of priorities (Saaty, 2013).

Based on the fundamental scale of AHP, when the degree of importance for criterion is between 1 to 9, the method of constructing a comparison matrix for the degree of importance is shown in Table 3.6. Likewise, constructing a comparison matrix when the degree of importance for criterion is between 1 to 5, is shown in Table 3.7.

Table 3.5: Fundamental scale of absolute numbers for pairwise comparison

Scale	One factor compared to another- degree of preference (importance)	Scale
1	Equal importance	1
3	More important	2
5	Strongly more important	3
7	Very strongly more important	4
9	Extremely more important	5
2,4,6,8	Intermediate values between adjacent scale values	-
Reciprocal of above	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i. (This is a logical assumption)	-

Source: Saaty (1980, 2008, 2013)

Table 3.6: How to construct the comparison matrix (1 to 9, with intermediate values between scale values)

importance	Extremely Unimportant (1) ←								→ Extremely important (9)
Extremely Unimportant (1) ↓	1	2	3	4	5	6	7	8	9
	1/2	1	2	3	4	5	6	7	8
	1/3	1/2	1	2	3	4	5	6	7
	1/4	1/3	1/2	1	2	3	4	5	6
	1/5	1/4	1/3	1/2	1	2	3	4	5
	1/6	1/5	1/4	1/3	1/2	1	2	3	4
	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3
	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2
Extremely important (9)	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1

Source: adjusted from Saaty (1980)

Table 3.7: How to construct the comparison matrix for (1 to 5)

importance	Extremely Unimportant (1) ←				→ Extremely important (5) *
Extremely Unimportant (1) ↑	1	2	3	4	5
	1/2	1	2	3	4
	1/3	1/2	1	2	3
	1/4	1/3	1/2	1	2
Extremely important (5) *	1/5	1/4	1/3	1/2	1

*Note: Utilising 5-point Likert scale; (1) indicates low importance and (5) indicates high importance

Source: adjusted from Saaty (1980)

To make the relative scale of priorities clear, an example may be useful. If there are three criteria ($n = 3$); then A1, A2, and A3 are considered, and the pairwise comparison matrix would be:

Table 3.8: An example pairwise comparison matrix

	A1	A2	A3
A1	a_{11}	a_{12}	a_{13}
A2	a_{21}	a_{22}	a_{23}
A3	a_{31}	a_{32}	a_{33}

a_{11}, a_{22} and a_{33} are the comparison of each criterion to itself, with a value of 1 (indicating equal importance). The value a_{12} is obtained by comparing A1 with A2, while a_{21} is the value of comparing A2 with A1, which is the reciprocal of a_{12} (i.e. $a_{21} = \frac{1}{a_{12}}$). The logical assumption of $a_{21} = \frac{1}{a_{12}}$ is for consistency in the numerical judgments (Saaty & Vargas, 1982). The matrix below is an example of the use of the fundamental AHP scale given in Tables 3.5 and 3.6.

- The lead diagonal entries $a_{11}, a_{22}\ and\ a_{33} = 1$,
- A1 is strongly more important than A2, so $a_{12} = 5$, and consequently $a_{21} = \frac{1}{a_{12}} = \frac{1}{5}$, and
- A3 is extremely more important than A1 (i.e., $a_{31} = 9$), so $a_{13} = \frac{1}{a_{31}} = \frac{1}{9}$.

$$\begin{bmatrix} 1 & 5 & \frac{1}{9} \\ \frac{1}{5} & 1 & 3 \\ 9 & \frac{1}{3} & 1 \end{bmatrix}$$

After creating the pairwise comparison matrix, the next step is to derive the priorities or weightings. Saaty (1980) proposed methods of computation of a vector of priorities from the given matrix. One method is: to sum up the values in each column of the pair-wise matrix and generate a normalised pair-wise matrix:

$$Sum\ a_{ij} = \sum_{j=1}^{n} a_{ij} \qquad (3.7)$$

For the above example matrix $Sum\ a_{ij}$ is: $10.2,\ 6.33$, and 4.11

also, the normalised matrix $(N)\ b_{ij} = \frac{a_{ij}}{Sum\ a_{ij}} = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} = \begin{bmatrix} 0.10 & 0.79 & 0.03 \\ 0.01 & 0.16 & 0.73 \\ 0.88 & 0.05 & 0.24 \end{bmatrix}$

Dividing the sum of the normalised row of the matrix by the number of criteria (n) will generate a weighted matrix:

$$W = \frac{\sum_{i=1}^{n} b_{ij}}{n} = \begin{bmatrix} w_{11} \\ w_{12} \\ w_{13} \end{bmatrix} = \begin{bmatrix} 0.31 \\ 0.30 \\ 0.39 \end{bmatrix}$$

Therefore, for $n \times n$ judgment/comparison matrix, there is a priority matrix W where $\sum w_{ij} = 1$.

Applying the AHP approach allocates fixed scale numbers for arbitrary units of those factors that are not mathematically measurable. However, the relative measurement of the fundamental scale of absolute numbers is not fixed and depends on the context of the problem and its objectives, in addition to people's ability to making distinctions among different things (Saaty, 1980, 2008, 2013; Saaty & Vargas, 1982). Therefore, a small change in the values used from the fundamental scale of numbers may lead to small changes in the derived priorities (Saaty, 2013). These derived priorities assist the researcher in weighing the different criteria of a complex problem. These weights need to be tested through the calculation of the principal eigenvector, which is a common method of estimation in a real situation (Saaty, 1980, 2013). The principal eigenvector λ_i is the value of the consistency vector.

$$\lambda_i = \sum_{j=1}^{n} a_{ij} w_i \qquad (3.8)$$

For $i = 1, \dots, n$ and $w_i =$ weight associated with the row i.

And λ_{max} is the largest eigenvalue to furnish the priorities, is calculated by averaging the value of the consistency vectors when n is the size of matrix:

$$\lambda_{max} = \max\left(\frac{\lambda_i}{n}\right) \qquad (3.9)$$

The consistency index (CI), which is an indicator of "closeness to consistency" measures the deviation of λ_{max} from n:

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (3.10)$$

This index evaluates the closeness of the derived scale from an underlying ratio scale, which the researcher wishes to estimate. In general, if this number is less than 0.1, the researcher may be satisfied with the judgment (Saaty, 1980). In addition, this index is useful, when it is compared with the appropriate consistency index called the Random Consistency Index. The random index for matrices of order n is defined as the expected value of the CI corresponding to matrices of order n when the judgments are simulated in the set {1/9, …, 1, …, 9} and the eigenvector method is used as the prioritisation procedure (Aguarón & Moreno-Jiménez, 2003; Donegan & Dodd, 1991). Saaty (1980) provided the random consistency indices for different matrix sizes, sown in Table 3.9.

Table 3.9: Appropriate random consistency indices for a range of criteria

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

Source: Saaty (1980)

Consistency Ratio (CR) is a comparison between CI and RI, $CR = \frac{CI}{RI}$ by Saaty (1980). If the value of $CR \leq 10\%$, inconsistency is acceptable, if the $CR > 10\%$, the researcher needs to revise the subjective judgment.

3.4.3.4 Developing an index

A composite index is an instrument to measure a multi-dimensional concept (OECD, 2008). To measure multi-dimensional concepts such as sustainability, resilience, or adaptive capacity, it has been suggested that composite indicators be used (Cutter et al., 2010; Dočekalová & Kocmanová, 2016; R. Nelson et al., 2010). The appeal of indicators and indices refers to their ability to summarise technical information and make it simple to understand (Davidson & Lambert, 2001). Depending on the purpose of an index, it can be either simple or weighted (Singh et al., 2007). Weighting the components for developing an index is subjective, depending on the researcher's choice (Booysen, 2002). The AHP is a weighting method that offers a logical path for decision-making and priority driving (Saaty & Vargas, 1982; Singh et al., 2007). Comparing the criteria by pairs, AHP assigns weights to reflect the criteria's relative importance to the decision-maker (Saaty, 2008). Therefore, each criterion has relative importance or weight (a_i) along with the score from the abovementioned PCA and EW methods as components to developing an index. The index is defined as below:

$$\text{Index} = \sum_{i=1}^{n} a_i \times \text{Score of Criterion}_i \qquad (3.11)$$

$i = 1, \dots, n$ where a_i is the relative importance of Criterion_i

The overall index is a linear combination of the weights derived by AHP (a_i) and the score of each criterion. Since the scores are calculated using two methods (PCA and EW), there will be two overall indices for each respondent. The next section represents the methods and data used to conduct this study and the results are presented in Chapter 5.

3.4.4 Summary of quantitative data analysis

Following a descriptive analysis of the data, two common weighting methods were carried out. Each statement in the survey gives rise to the variables. Principal Component Analysis (PCA) weighting and Equal Weighting (EW) to compose a score of variables for further analysis. Regarding the seven dimensions, scores were calculated for each dimension. Then through AHP, the relative importance of each dimension (criteria) was calculated and used to develop an index of perceived adaptive capacity. Also, the relative importance of sub-

criteria for human capital and social capital were calculated to have more detailed insight into each farmer's perceptions of these two capitals.

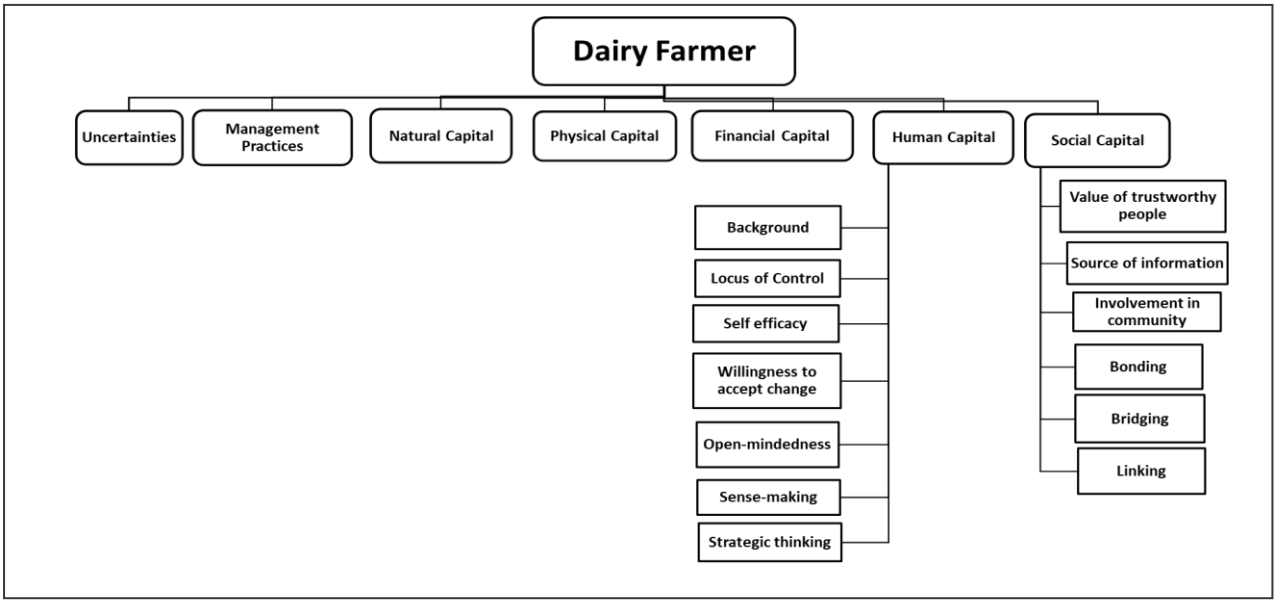
Through PCA, dealing with missing data, sample size issues, extracting the first component, and calculating PCA scores were considered. Firstly, since there were 65 useable responses in this study with no specific pattern of missing data, the pair-wise deletion method was used for handling the missing data, avoiding a substantial loss of information through the deletion of cases. Secondly, although the questionnaire was broad and included statements relating to the seven dimensions, the PCA was used separately for each set of statements relating to each dimension. Thus, the sample size was satisfied based on N:p ratios (respondent: question ratios), the KMO test, and Bartlett's Test of Sphericity. Thirdly, utilising the first component was a bottom-up process, in which PCA weighting started for the attributes of human capital and the aspects of social capital. Then the calculated score for the attributes and the aspects went for another PCA weighting to calculate a score for human capital and social capital. Finally, seven scores for seven dimensions were calculated for each farmer. Every score was computed by multiplying the original variable score (on the five-point scale) by its component coefficient (weight) and then summing the values. For the EW method, the variables were weighted equally for calculating scores of seven dimensions. It was the sum of the original Likert scale divided by the number of variables for each farmer.

In the bottom-up process, first, the weight of each statement pertaining to attributes of human capital and aspects of social capital (per participant) was used to create a score for them[9]. Second, these scores, in turn, were used to create a score for human and social capital. Moreover, the weight of each variable pertaining to the other five dimensions (uncertainty, management practice, natural capital, physical capital, financial capital) was used to create a score for them. Third, the score for each of the dimensions from the PCA weighting or the EW was used for the next step, the Analytical Hierarchy Process (AHP).

[9] These scores also were used to assign relative importance for human capital attributes and social capital aspects through the AHP. The relative importance of sub-criteria for human and social capital helps to have more detailed insight into each farmer's perceptions of these two capitals.

Through AHP, two stages were considered: hierarchy construction and pairwise comparison (Saaty, 1990). Firstly, to construct the hierarchy, the seven dimensions in this research were considered as the seven criteria of the AHP. The sub-criteria of the human and social capitals were defined based on the literature. Figure 3.7 is a specified AHP hierarchy figure for a dairy farmer with seven dimensions.

Figure 3.7: AHP hierarchy for perceived adaptive capacity



Secondly, the final scores for the seven criteria were used in the AHP based on the pairwise comparison Table 3.5 (Section 3.4.3.3). This comparison provided the relative importance of the seven criteria to develop a perceived adaptive capacity index for each dairy farmer. The scores through the PCA were not one to five. Rather, the degree of importance for criterion took place between 1 to 9. Therefore, constructing a comparison matrix for the degree of importance was done based on Table 3.6. Moreover, the scores through the EW were 1 to 5. Therefore, constructing a comparison matrix for the degree of importance was based on Table 3.7.

For two weighting methods (PCA and EW), through AHP, the relative importance (weights) of each criterion and the score of each criterion were used as components to develop a perceived adaptive capacity index. Two Perceived Adaptive Capacity Index (PACI) were developed for every farmer regarding the relative importance of each criterion and the score of that criterion assigned for PCA and EW. PACIa for PCA score and PACIb for EW score. The results are reported in Chapter 5.

Chapter 4 : Qualitative results

4.1 Introduction

As mentioned in Chapter 3, the exploratory sequential mixed method (Johnson & Christensen, 2017) was chosen as the most appropriate design for this study. This method included a qualitative phase that used a multiple-case study approach (Creswell & Poth, 2016) and involved the collection and analysis of data from four case farmers. The results from the multiple-case study along with relevant literature were then used to help develop a survey instrument for the quantitative phase. Since resilience in dairy farming is a relatively new research area, and little is known about the adaptive capacity of New Zealand dairy farmers, a qualitative exploratory study was used to explore the dimensions of the conceptual framework of perceived adaptive capacity for New Zealand dairy farmers. The conceptual framework used for this study includes disturbances that impact the farmers, the farmers' perceptions of the five capitals (natural, physical, financial, human, and social) within their farm business that help them cope with disturbances and the management practices they used in association with these capitals to address uncertainties.

To explore the dimensions of New Zealand dairy farmers' perceived adaptive capacity, the objectives of the qualitative phase were:

1) to identify what external and internal disturbances (shocks and stresses) the case farmers had experienced in the past 5 – 10 years and also those that they expected to encounter in the future,

2) to identify the case farmers' perceptions of how important the various capitals were for coping with the different shocks and stresses, and

3) to identify management practices affecting the utilisation of the capitals of a dairy farming business.

In this chapter, section 4.2 describes the important characteristics of the case farmers and their farms and highlights any important similarities or differences. As part of this process, the case farmers are compared in relation to their five capitals. Following this, the results from the cross-case analysis are presented. The disturbances faced by the four case farmers

are described and compared in section 4.3. The disturbances are divided into shocks and stresses and then further subdivided into internal and external shocks or stresses[10]. Sections 4.4 and 4.5 describe the role of the capitals in the management of the shocks and stresses they have faced or expect to face. These sections also describe the perceived importance of the capitals to the case farmers in relation to the management practices they use to cope with the different shocks and stresses. Finally, the findings from qualitative phase brought insights into the design of the survey instrument for the quantitative phase of the research.

4.2 Farm and farmer characteristics

The important characteristics of the four cases are presented in this section. The case farmers were from both the North and South Islands of New Zealand and were selected to provide a different portfolio of the five capitals because it was assumed that these five capitals were important for managing the different disturbances. Compared to the regional data (DairyNZ, 2019) presented in Table 4.1, cases 3 and 4 can be classified as large and very large farms respectively. In comparison, case 1 is classified as a medium-sized farm and case 2 is classified as a small farm.

Table 4.1: A comparison of the case farms to regional data

Region (average/case)	Taranaki (Case1)	Manawatu (Case 2)	Wairarapa (Case3)	Canterbury (Case4)
Herd size average	294	408	376	799
Case herd size	**287**	**180**	**440**	**2595**
Farm size average (ha)	106	153	138	233
Case farm size	**99**	**65**	**200**	**705**
The scale	**Medium**	**Small**	**Large**	**Very Large**

The general characteristics and performance of the four case farm businesses are shown in Table 4.2. The ownership structures of the four cases are shown in Table 4.2 and cover the diversity of structures found in New Zealand dairy farming systems.

[10] Shocks and stresses (external/internal) are defined in Section 4.3.

Table 4.2: Case farm characteristics and performance

Characteristics	Case 1	Case 2	Case 3	Case 4
Ownership structure	Owner-non-operator & Equity partner	Owner-operator	50-50 Sharemilker	Owner-operator
Stage of the farm family cycle	Consolidation (Planning to work on improving farm performance)	Consolidation (Planning to buy some extra land)	Consolidation (Planning to be farm owner)	Consolidation (Planning for a stocking rate reduction)
Total dairy farming experience (years)	42	36	13	30
Years of operation for the current farm (years)	37	11	4	30
Location	Taranaki	Manawatu	Wairarapa	South Canterbury
Farm system (1 to 5)	3	3 to 4*	2 to 3*	3
Milking system (TAD, OAD, combination of TAD & OAD)	TAD	TAD & OAD	TAD & OAD	TAD
Effective milking platform (ha)	99	65	200	705
Cow numbers	287	180	440	2,595
Total Kg MS produced	134,000	90,000	175,000	1,270,540
MS (kg)/ha	1,354	1,385	875	1,802
Stocking rate – cows peak milked/ha	2.9	2.8	2.2	3.7
MS (kg)/cow	467	500	398	490
Pasture grown per annum (kg/DM/ha/year)	14,200	12,000-14,000	9,500	16,000

*Note: The level of supplement feeding, and the amount of imported feed vary depending on the season and pasture deficit during a year, hence a range is provided.

Case 1 is an owner-non-operator for the first farm and holds an equity partnership in a second farm located in another region. For the study, the case farmer discusses his viewpoints as the main decision-maker on the first farm. Two of the cases (2 and 4) have an owner-operator structure. Case 3 is a 50-50 sharemilker, so he shares farms on a property owned by another farmer. He owns the herd and the other farmer owns the land and infrastructure. The case farmer receives 50% of the milk income and pays a proportion of the operating costs for the farm. All four case farms are in a period of consolidation where they are working to improve performance in different ways. Case 1 is planning to work on improving farm performance, in which profit-making is the main incentive. Case 2 is planning to buy some extra land to expand their operation by increasing their cow numbers

and increasing both their scale and their cash surplus from farming. Case 3 is a 50-50 sharemilker who is planning to be a farm owner. In contrast, case 4 expects to have to reduce stocking rate change because of new regulations that will be introduced in the future to reduce nitrogen leaching to fresh water. The total years of dairy farming experience vary from 13 years (for case 3) to 42 years (for case 1). Also, the number of years that the case farmers have farmed their current farms ranged from 4 years (for case 3) to 37 years (for case 1). The four case farms are in different regions. Case 1 is in Taranaki, which has a benign climate with high rainfall all year round. However, case 2 is in the Manawatu and case 3 is in the Wairarapa, where the weather is more variable and pasture growth rates are more unpredictable that cases 2 and 3 both experience dry summers. Case 4 is in South Canterbury, which is a low rainfall region, so they cannot farm dairy cows without irrigation.

Although dairy farming in New Zealand is pasture-based, farmers use different levels of imported feed[11]. DairyNZ, the industry good organisation for New Zealand dairy farmers has defined the country's dairy farms on the basis of the level of imported feed they use and classified farm systems from system 1 which uses no imported feed or off-farm grazing to system 5 in which 25 - 40% (but it can be up to 55%) of the total feed is imported. Cases 1 and 4, define their farm systems as a system 3, in which 10-20% of the total feed is imported to extend lactation in spring and autumn. Case 2 is a system 3 to 4, in which 10-20% to 20-30% of the total feed is imported. In contrast, case 3 is a system 2 to 3, in which 4-14% to 10-20% of the total feed is imported. There is a difference in risk exposure between these system types; systems 1 & 2 are more exposed to production risk (climatic variation), but not market risk in terms of purchased feed, whereas systems 3, 4 & 5 are less exposed to production risk, but more exposed to market risk for bought-in feed.

The milking system for cases 1 and 4 is twice-a-day (TAD), while a combination of once-a-day (OAD) and twice-a-day (TAD) milking is used by cases 2 and 3. This is because cases 2 and 3 change to once-a-day milking in summer and autumn to help manage feed shortages due to dry summer conditions. Cases 1 and 4 do not have this problem and are less affected

[11] The five production systems have been described by DairyNZ primarily on the basis of when imported feed is fed to dry or lactating cows during the season and secondly by the amount of imported feed and/or off farm grazing that is used (DairyNZ, 2012). The five production system definitions are in Appendix 1.

by climate variation. This is because case 1 is in Taranaki, which has a benign climate and case 4 is in South Canterbury and 100% of the farm is irrigated. In contrast, cases 2 and 3 are in the Manawatu and Wairarapa regions and these regions have much greater variation in rainfall over summer.

Farm size varies from 65 ha for case 2 (a small farm) to 705 ha for case 4 (a very large farm). As a reflection of farm size, herd size ranges from 183 to 2,595 cows. Similarly, total milk solids production varies from 90,000 kg MS for case 2 to 1,270,540 kg MS for case 4. Milk solids production per hectare ranges from 875 kg MS/ha to 1805 kg MS/ha. The drivers of these are stocking rate and MS/cow. Case 3 has the lowest milk solids production per hectare because it has the lowest stocking rate (2.2 cows/ha) and the lowest milk solids production per cow (398 kg MS/cow). Case 4 produces the most milk solids per hectare because it has a much higher stocking rate than the other farms (3.7 cows/ha) and produces the second highest level of milk solids per cow (490 kg MS/cow). Cases 1 and 2 produce similar levels of milk solids per hectare because they run similar stocking rates and achieve similar levels of milk solids production per cow (Table 4.2). A key driver of milk solids production per hectare is pasture grown per hectare, but one must also consider the amount of imported feed. Annual pasture production varies from 9,500 kg DM/ha (for case 3) to 16,000 kg DM/ha (for case 4) with cases 1 and 2 growing 12,000 – 14000 kg DM/ha per annum. Cases 1, 2, and 4 also import in a lot more feed than case 3, with case 2 buying in more feed than cases 1 and 4.

When comparing cases in relation to the case farmers' perceptions of the importance of their five capitals for coping with shocks and stresses, it is useful to compare the capitals that each case farmer has access to. In the following sections, the five capitals (natural, physical, financial, human, and social) of the four case farmers are compared and contrasted.

4.2.1 The case farms' natural capital

The portfolio of natural capital a farm has, sets the potential for annual pasture production (Hein et al., 2016) which in turn is a key driver of lower-cost production per hectare (Hanrahan et al., 2018). The natural capital that drives annual pasture production includes the soil type(s), altitude, climate, and the contour or topography of the farm (Dominati &

MacKay, 2015; Lusardi et al., 2018). The degree to which a farm meets its potential in terms of pasture production per hectare per annum will also depend upon the other capitals that are described in the following sections. The important elements of natural capital for the case farms are described in Table 4.3.

Table 4.3: Case farm characteristics related to natural capital

Characteristics	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Location	Taranaki	Manawatu	Wairarapa	South Canterbury
Rainfall (mm/annum)	2,000-3,000	1,300- 1,500	2,100	650
Altitude (m a.s.l.)	200	11	240	127
The natural fertility of the soil (High/Medium/Low)	Medium	High	Medium	Low
Soil type	Allophonic volcanic ash	Silt loam with clay base underneath	Stony silt loam	Stony silt loam
The natural drainage of the soil (High/Medium/Low)	High	Medium - Low	High	High
Land topography of the milking platform	95% Flat	Flat	Terraced Flat	Flat
Effective milking platform (ha)	99	65	200	705
Non-milking area (runoff) (ha)	6	4	45	215

Farm location often dictates important aspects of a farm's natural capital such as climate and soil type. Case 1 in the Taranaki region has high annual rainfall, while for regions like the Manawatu and Wairarapa, the annual rainfall is less (Table 4.3) and more variable, especially during the summer. Cases 2 and 3 have to put in place management strategies to cope with the lower and more variable rainfall such as changing from twice-a-day to once-a-day milking in summer (See the following quote). Case 4 is in a low rainfall region and has to rely on physical capital in the form of irrigation to grow sufficient pasture to farm dairy cows.

> *"So, we milk the cows twice-a-day till say either early Christmas, like Christmas day or 1st February depending on the season [and then go to once-a-day milking]. We went a bit early this year [to once-a-day milking] just because it was so dry it's just ridiculous and so hot". (Case 2)*

The altitude varies from 11 meters above sea level for case 2 in the Manawatu to 240 meters above sea level for case 3 in the Wairarapa. Altitude influences climate and the climate influence the pattern of pasture growth (Hein et al., 2016); the higher the altitude,

the shorter the growing season (Ngetich et al., 2014). Altitude also influences the variability of pasture growth; the higher the altitude, the greater the variability (Körner et al., 1986). From a traditional agricultural approach, the natural fertility of the soil includes biological, chemical, and physical parameters with a focus on the productive functions of soils (Sanchez et al., 2003). There is a soil classification system that shows soil diversity in New Zealand (Hewitt & Dymond, 2013). The classification system is based on a set of soil stocks as natural capital. In this vein, natural soil fertility provides benefits for enhancing pasture growth for dairy farming. The case farmers rated the natural soil fertility of their farms, which is medium for cases 1 and 3, high for case 2, and low for case 4. Another important characteristic of the farms' natural capital related to location is the soil type. The Allophonic volcanic ash soil type on case farm 1 and the stony silt loam soil types on case farms 3, and 4 provide free draining soils that are less prone to pugging and soil compaction. In contrast, case farm 2 has a soil type that is a silt loam with a clay base underneath that results in poor drainage and problems with pugging and soil compaction. Topography is also important because it influence through the effects of slope (Lambert, 1976; Radcliffe, 1982). In this vein, all four case farms are reasonably similar in that almost all of the milking platform on each farm is flat.

The effective area of the milking platform or the scale of dairy farming is one of the most important factors that determine the economic performance of a dairy farm (Beux Garcia, 2013). Since natural capital sets the potential for pasture production per hectare, it is an important driver of per hectare profitability. For the case farmers, the scale varies from 65 ha for case 2 to 705 ha for case 4. It is seen that case 4 and to a lesser extent case 3 have a significant advantage in terms of scale compared to cases 1 and 2. Case 2 is disadvantaged in terms of scale with the farm just over half the size of the average Manawatu dairy farm (153 ha). So, case 4 has the greatest advantage in terms of scale and case 2 has the least. In terms of natural capital in relation to potential pasture production, case 1 would be the best case because of its location in a benign region while case 4 is the worst because it is in a region with low rainfall, and it needs physical capital (irrigation) to be able to run dairy cows.

Runoffs are blocks of non-milking land that provide dairy farmers with options for producing feed (hay, silage, maize silage) and grazing (for dry cows and replacements) for the dairy farm. This provides the farmers with greater control over feed inputs, and the rearing of

young stock. Surplus dairy stock or other stock can be reared on runoff to provide additional income. However, it does come at a cost, and the purchase of runoff will increase the debt levels of a farmer. Table 4.3 shows that case 4 has a large runoff and case 3 has a moderate-sized runoff, but cases 1 and 2 have limited runoff areas.

Natural capital is a capital that the farmers have little control over after deciding the location of the farm. Thus, the location, rainfall, drainage, land topography influence how natural capital works for the farmers. The next section compares the physical capital on the four case farms.

4.2.2 The case farms' physical capital

Physical capital comprises the tangible assets used in the production process (Kataria et al., 2012). These tend to be capital items that the case farmers have invested in e.g., capital fertiliser, pasture species, livestock, infrastructure, and machinery. The physical capital for the four case farm businesses is shown in Table 4.4.

Some of the physical capital listed in Table 4.4 has been invested in the farms to overcome some of the limitations of the farms' natural capital such as soil fertility, poor natural drainage, or a lack of rainfall. The case farmers use different fertilisers mixes that are determined by their soil fertility targets. The farmers aim for particular Olsen P and soil pH targets. Olsen P is a measure of soil fertility. For example, the target for ash and sedimentary soils which are the soil types on the case farms, is to have an economic optimal Olsen P range of around 30 – 35 when low producing (< 1000 kg MS /ha) and around 35-40 when high producing (>1000 kg MS /ha) (DairyNZ, 2012).

Table 4.4: Case farm characteristics related to physical capital

Elements	Characteristics		Case 1	Case 2	Case 3	Case 4
Fertiliser (Kg/ha)	P		55	Unknown	45	35
	N		180	60	54	230
	K		80	Unknown	100	44
	S		65	Unknown	50	49
Soil	Soil Olsen P level		35	26-28	28	32
	Soil pH		5.9	5.8-6.2	5.9	6.2
Infrastructure	Artificial drainage system		No	The whole farm has got tile & mole drains under it	No	No
	Feed pad		150-cow, beside the cowshed	No	300-cow, beside the cowshed	No
	Farm irrigated (%)		0%	0%	0%	100%
	Milking Shed type and size		40 bail rotary	24 aside herringbone	36 aside herringbone	One 50 bail rotary + two 60 bail rotaries
	Is the Effluent system built for shocks or future consent changes?		Yes, some surplus capacity	Yes, the new consent is for 320 cows	No, it needs upgrading	Yes
	Area irrigated with effluent		12 ha	24 ha	35 to 60 ha	461 ha
	Is the irrigated area enough?		Yes	Yes	No	Yes
	Runoff area		6	4	45	215
Cows	Cows milked at peak		287	180	440	2,595
	Breed of cow		Friesian cross	Kiwi cross	Kiwi cross	Friesian-Jersey cross
	BW-PW		85 - 116	Unknown	110 - 130	142 - 170
pasture	Pasture Species		Ryegrass and white clover	Ryegrass and white clover	Ryegrass and white clover	Ryegrass and white clover
	Pasture grown (kg DM/ha/year)		14,200	12,000-14,000	9,500	16,000
	Estimated pasture from N (kg DM/ha/year)*		1800	600	540	2300
Feed supplementary (kg DM/ha/year)	Feed grown on farm	Forage crops	Turnip - 757	Rape 415 & Chicory 2,076	-	-
		Hay and silage	-	31	Grass silage - 545	-
		Feed from nitrogen	-	-	-	-
	Bought in feed	Maize silage	1,515	-	-	-
		Bought-in hay or silage	-	-	Hay - 195	-
		Grain	-	-	-	Barley - 1,104
		PKE	2,222	769	500	-

*This is part of the total in the previous row (Pasture grown (kg DM/ha/year))

Case 1 is producing 1,354 kg MS/ha, so, the Olsen P for case 1 is optimum (Table 4.4). However, case 2 which is producing 1,385 kg MS/ha, has an Olsen P that is below optimum. Case 3 is producing 875 kg MS/ha, so the Olsen P is slightly below optimum. Case 4 is producing 1,802 kg MS/ha, so as a high producing farm, their Olsen P is below optimum. The optimum range for soil pH for pasture production is 5.8 – 6.2 for mineral soils and 5.0 – 5.5 for peat soils (DairyNZ, 2012). All four case farms have soil pH levels that are in the optimum range. Cases 1 and 4 use nitrogen more than the other two cases. Nitrogen is applied to grow additional pasture and produces about 10 kg DM/kg N [12]. It is shown in Table 4.3 that the natural fertility of the soil for cases 1 and 4 is medium and low respectively. So, they compensate for this fertility shortage by applying nitrogen. While case 2 benefits from high natural soil fertility, case 3 is in a sensitive catchment area that restricts their nitrogen fertiliser use. The case farmers have invested in capital fertiliser to improve the soil fertility of their farms and apply maintenance fertiliser to maintain soil fertility levels.

Only case farm 2 has a tile and mole drainage system because it has soils with poor natural drainage. In contrast, the other three case farms do not have artificial drainage because they have free-draining soils. Often farms with drainage problems use feed pads, but case farmer 2 does not do this. The milking shed is a physical capital item that is critical for the harvesting of milk on a dairy farm. Importantly, the choice of milking shed does affect the amount of labour a farmer requires to milk his herd. For large herds, a rotary milking shed will be the farmer's preference because it can be used to milk a large number of cows with limited labour. The key to milking efficiency in a rotary milking shed is to maximise the time of milking[13]. Case 4 which is a large-scale dairy operation has one 50-bail rotary plus two 60-bail rotaries to milk their 2,595-cow herd. In the same way, case 1 has one 40-bail rotary for their 287-cow herd. However, cases 2 and 3 use an herringbone shed, but this imposes a higher workload on them and their staff. The trade-off, however, is that less financial capital investment is required for a herringbone shed compared to a rotary.

The other physical capital items that the case farmers have invested in include an effluent system. All four cases have an effluent system to manage their wastewater, and this is a

[12] https://www.dairynz.co.nz/feed/pasture/growing-pasture/managing-nitrogen-fertiliser/

[13] https://www.dairynz.co.nz/milking/milking-efficiently/milking-routine/rotary-routine/

standard requirement on New Zealand dairy farms to meet regulatory requirements. The effluent systems in cases 1, 2, and 4 have sufficient storage capacity and the area onto which the effluent is irrigated to meet regulatory requirements. However, case 3 does not have a sufficient area on which the effluent is irrigated. They have consent to irrigate 35 ha with effluent, but they need consent for 60 ha because of the amount of effluent the farm produces. As such, case farmer 3 is exposed to regulatory risk because he is irrigating a much larger area with the effluent than he has consent for. Cases 3 and 4 have large runoffs that are a source of feed for their systems, whereas cases 1 and 2 only have small runoff areas (Table 4.4). As with the cowshed type, although the larger runoffs will provide more feed to case farms 3 and 4, there is a trade-off because of the financial cost of purchasing a larger runoff.

Cow numbers are an indicator of farm-scale and this ranges from 180 cows for case 2 which would be considered small in the New Zealand context to 2,595 cows for case 4 which would be considered large. The average herd size in New Zealand is 435 cows (DairyNZ, 2019). All the case farms are running some form of cross-bred cow whether it is a Friesian-cross for case 1 or Kiwi-cross cows for cases 2 and 3, and Friesian-Jersey-cross cows for case 4. Related to the breed of cows, Breeding Worth (BW) and Production Worth (PW) are indices that are used to rank cows according to their genetics and ability to efficiently convert feed into profit over their lifetime[14]. Case 4 has the herd with the highest genetic merit with a BW and PW at 142 and 170 respectively. Cases 1 and 3 have lower BW and PW scores and case 2 does not have information about the BW and PW for their herd.

The pasture species on most New Zealand dairy farms comprise ryegrass and white clover (DairyNZ, 2015). Pasture production per hectare per annum is the highest for case 4 and the lowest for case 3. In addition, the farms have other crops grown on-farm and bought in feed to feed their herd when it is required.

[14] https://www.dairynz.co.nz/animal/animal-evaluation/animal-and-herd-averages/#category=sires&breed=all&status=ras

4.2.3 The case farms' financial capital

The other form of capital for a farm business is its financial capital (Lockwood et al., 2015; Nettle et al., 2018). More resilient farms tend to be more profitable, have lower debt, and a higher return on assets (Shadbolt et al., 2013). These are known as financial performance measures and are used to measure the financial situation of the business to achieve business and financial targets (Shi & Yu, 2013). Scale is also important because a larger farm tends to produce more discretionary cash than a smaller farm (MPI, 2012). The case farms' financial capital is presented in Table 4.5.

Table 4.5: Case farm characteristics related to financial capital (the year 2017)

Characteristics	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Total assets	$ 7.7 M	$ 5.5 M	$ 1 M	$50 M
Debt: Assets	36%	35%	60%	40%
Net income/ha	$1,891	$1,742	$534*	$2,608
Effective area (ha)	99	65	200	705
Total net income	$187,209	$113,230	$106,800	$1,838,640
The total return on assets	2.4%	2.1%	10.7%	3.7%
Scale	Medium	Small	Large	Very large

*Net income for a sharemilker is half of the total return of the farm, which is $1,068

Firstly, the total assets are used to calculate several ratios to assess a business's financial status (Shadbolt & Martin, 2005). The total assets vary from $1M to $50M for the case farms. This is because of the scale of the farms and the ownership structure. The total assets are the highest for case 4 which is a large owner-operator farm. In contrast, the other two farms owned by the case farmers are medium and small-sized farms. Case 3 has the lowest total assets, and this is because they are 50-50 sharemilkers and only own the herd, replacement stock along with the plant, machinery, and vehicles. They do not own the land.

Secondly, the debt to asset ratio can be used as an indicator to measure a business's financial leverage (Hovakimian et al., 2004; Myers, 2001). A business's liabilities (debt) and equity build its assets (Shadbolt & Martin, 2005). Shadbolt and Martin (2005) mentioned that when assets exceed liabilities, the business is solvent. In contrast, when liabilities exceed assets, the business is insolvent. Therefore, the debt to asset ratio shows the business situation in this regard. Higher ratios usually indicate that a business may be at risk of defaulting on loans, especially if interest rates increase (Hovakimian et al., 2004). Also, it was stated that the debt to assets ratio is a useful indicator of how vulnerable a business is

to shocks or stresses (Alstadsæter et al., 2020). The higher the debt to asset ratio, the more vulnerable the farm business is to shocks and stresses (Prager et al., 2018). The data shows that the owner-operators, cases 1, 2, and 4, have a relatively low debt to asset ratio compared to the 50-50 sharemilker, case 3. This means that cases 1, 2, and 4 may likely be less vulnerable to shocks and stresses relative to case 3. The asset base for the sharemilker is also more variable than for the other case farms because cow prices are more volatile than land prices.

Thirdly, net income or the farm cash surplus, the so-called 'bottom line' is the cash from the farm operation that remains after all the cash expenses of the business have been deducted from the income (Shadbolt & Martin, 2005). To compare the farms, net income per hectare is presented in Table 4.5, and this is useful measure of economic efficiency (Lopez-Villalobos et al., 2000). It demonstrates that case 3 has the lowest net income/ha and case 4 has the highest net income/ha. The total net income figure shows the effect of scale and net income per hectare (Table 4.5). For example, although cases 1 and 2 have similar per hectare figures, the larger scale of case 1 provides it with a much greater total net income. Similarly, Case 3's net income per hectare is only 31% of that of case 2, but because of his larger scale, his total net income per annum is 94% of that of case 2. Case 4 shows the benefit of high net income per hectare and scale with a total net income per annum that is 9.8 to 17.2 times that of the other three cases.

The final figure in Table 4.5 is the total return on assets ratio, which is an indicator of how effectively a business is at using its assets to generate earnings (Jewell & Mankin, 2011). It is calculated by dividing a farm business's net income by total assets. The total return on assets ratio is 2.1% for case 2, the lowest among the four cases. This is because case 2 lacks scale. The total return on assets is higher (2.4%) for case 1 and 3.7% for case 4. However, it is much higher for case 3 (10.7%), since the return on capital for sharemilkers is always higher than for a farmer who owns cows and land (normally around 2 – 3%). This is related to the ownership structure where sharemilkers tend to make a higher return on assets because they do not have capital tied up in land (Buchanan, 2002).

4.2.4 The case farms' human capital

In addition to natural, physical, and financial capital, a farm business's human capital is very important in farm management. The characteristics of human capital are related to the quantity and the quality of labour on a farm, where the quality of labour is mostly related to the knowledge and skills of the farm owners and the staff (Kataria et al., 2012; Pennings et al., 1998). Dairy farms in New Zealand are mostly owned and operated by a farming couple who are the primary decision-makers on the property (Jay, 1999; Wilson & Tipples, 2008). As such, their knowledge and skills are more important than that of their staff. Their age, education, and experience influence their decision-making capability. The characteristics of the cases in relation to human capital are shown in Table 4.6.

The ages of the farmers from these four cases are different. The oldest farmers in the study are case 1, the husband is 63 years old, and the wife is 61 years old. On the other hand, the youngest farmers in the study are case 3. For the sharemilkers, the husband is 35 years old, and the wife is 30 years old. Farming experience is one indicator of human capital. The most experienced is case 1 and the least experienced is case 3, which is expected because of the farmers' ages.

Among the four cases, cases 1, 3, and 4 all have a tertiary education, but case 2 does not. Of the three with tertiary qualifications, case 3, the least experienced farmers have the best education in terms of agriculture, closely followed by case 4, and then case 1.

The roles in a dairy farm business include production management, financial management, HR management, and strategic management. The husbands are involved in all these roles, while the wives are mostly involved in the financial management of their farms. Also, the wives of cases 2 and 3 are involved in production management. For example, Case 2 mentioned:

> *"I don't like facts and figures as much. [My wife] would bring the laptop to bed and show me the budget before we went to sleep. You know like this is what we need to do… At the moment [she] does every milking". (Case 2)*

Table 4.6: Case farm characteristics related to human capital

Characteristics	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Age of Partner 1 (Husband)	63	44	35	50
Age of Partner 2 (Wife)	61	35	30	49
Dairy farming experience and involvement (Partner 1)	42 years	26 years	13 years	30 years
Dairy farming experience and involvement (Partner 2)	35 years	17 years	6 years	25 years
Education (Partner 1)	Bachelor of Agriculture Science and Master of religious education	Finished high school	Bachelor of Applied Science (Agribusiness)	Diploma in Agriculture Science
Education (Partner 2)	Bachelor of Education and a teaching certificate	Finished high school	Bachelor of Business studies, marketing, and human resources	Bachelor of Agriculture
Role in the business (Partner 1)	Production, financial, HR, and strategic management	Production, financial, HR, and strategic management	Production, financial, HR, and strategic management	Production, financial, HR, and strategic management
Role in the business (Partner 2)	Financial, HR, and strategic management	Production, financial, HR, and strategic management	Production, financial, and HR management	Financial, HR, and strategic management
Background (Partner 1)	Dairy farming	Dairy farming	Dairy farming- Commercial firewood processing and selling- Contract fencing – some manufacturing	Dairy farming and Sheep & Beef farming
Background (Partner 2)	Town background	Town background	Town background	Town background
Non-family staff Numbers (FTE)	1.00	0.00	0.75	14.00
Family staff Numbers (FTE)	0.75	2.00	1.25	2.00
Total staff Numbers (FTE)	1.75	2.00	2.00	16.00
Cows milked per FTE	164	90	220	162

Production management is part of cases 2 and 3's wives' roles. This is because of their age and the financial situation of the business in which the younger couples mostly rely on their wives for help on the farm. For all four cases, the dairy farming couple's roles are complementary, and they jointly manage their farm businesses.

The four cases are similar in that the first partner (husband) had a farming background before marriage, while the second partner (wife) comes from an urban background and became involved in farming once she married her husband. The staff numbers (family +

nonfamily) in terms of full-time equivalents depend on the farm scale. It varies from 1.75 for case 1 to 16.00 for case 4 (Table 4.6). Case 2 is smaller than case 1, but both the husband and wife on this farm are involved with the on-farm physical work, while for case 1, the wife is not at all involved with the physical work on the farm. Instead, she is involved in strategic decision making and financial work. Hence, despite case 2 being smaller than case 1, the number of full-time equivalents that work on the farm are higher. In addition, the workload for case 3 is higher than the other three cases because of the farm scale and the low number of staff.

4.2.5 The case farms' social capital

The fifth type of capital for a farm family is its social capital. Social capital comprises the networks and relationships they have with other people in their community (Woolcock, 1998), the trust they build with other individuals and organisations in their networks, and the social norms that influence such networks (Coleman, 1988; Woolcock & Narayan, 2000). Social capital provides farmers with access to emotional support, information, knowledge, and resources and it can also result in collective action (de Krom, 2017; Woolcock & Narayan, 2000). These are all important in relation to adaptive capacity and coping with disturbances (shocks and stresses) (Béné et al., 2014; DFID, 1999). Indicators of the level of social capital for the four case farm businesses are shown in Table 4.7.

An important aspect of social capital is what forms of social capital (bonding, bridging, and linking) farmers access for emotional support, resources, information, and knowledge (Poortinga, 2012). The information provided in Table 4.7 helps to compare the case farmers' networks based on size and variety, however, it does not provide information about the quality of the social capital within those networks. This quality can be measured in terms of the people who can provide the farmer with good emotional support, information, knowledge, and resources to cope with a disturbance. As mentioned in the literature, "personality shapes individuals' ability to create social capital" (Tulin et al., 2018, p.295). However, the difference between the case farmers' priority for social capital is also likely to be a result of their ownership structure, age, the stage of the farm family cycle, and the farm location.

Table 4.7: The case farms' characteristics related to social capital

Characteristics	Case 1	Case 2	Case 3	Case 4
The networks the farmers rely on				
In terms of decision making or when facing a critical situation, to what extent do you rely on advice from family, friends, and neighbours?	Medium to High	Low to Medium	High	Medium
To what extent do you rely on Rural professionals – vets, consultants, reps, bankers, accountants, DairyNZ staff, etc. for such advice?	Medium	Low	Medium	High
To what extent do you actively build networks with regional council staff and any other people in positions of power over the farm to foster the business.	Medium	Low	High	Medium
Membership of boards or advisory committees or industry groups	Yes	No	Yes	Yes
Membership of a farmer discussion group	Yes	No	Yes	Yes
Membership of different groups	Taranaki farm discussion group	No	Convener of the local discussion group	Fonterra shareholder council, Lincoln dairy farm advisory board, DairyNZ discussion groups
Membership of other social networks	Church	No	The local school board of trustees	No
How do you describe your networks?	Many	Some	Many	Many
Who is your main emotional support when facing a critical situation?	Wife/ Husband	Wife/Husband	Wife/ Husband	Wife/ Husband
The use of different sources of information				
Consultant, advisor, and rural professionals	Occasionally	Occasionally	Often	Often
Discussion group	Often	Occasionally	Often	Often
Academics	Occasionally	Occasionally	Occasionally	Occasionally
The Internet	Often	Often	Often	Frequently
Newspaper, Magazine, mass media	Rarely	Rarely	Rarely	Rarely

Case 1 is an owner-non-operator and equity partner who is close to retirement, intending to improve the farm performance in a benign region. They stated that bonding social capital was more important than bridging or linking social capital for them, while they use bridging and linking social capital when they need to make strategic decisions.

Case 2 are a young couple who are owner-operators in a region with variable weather, and they are planning to buy some extra land near their farm. They rated their reliance on bonding, bridging, and linking social capital as low, so they do not view their networks as that important when faced with a disturbance. However, it was clear that the couple is highly reliant on each other in terms of emotional support and decision-making. This was a demonstration of the importance of bonding social capital for them. In terms of bridging and linking, the couple prefer to work with a small network of people, with the aim of having a small number of high-quality people in their network.

Case 3 are young, 50-50 sharemilkers, who are planning to be farm owners. They operate in a sensitive catchment and a region with variable weather. They need to be more attentive to regulations than the other three cases because of farming in a sensitive catchment. They have expanded their linking social capital to obtain more information and support from people in positions of power in relation to water quality regulations, i.e., their regional council. They stated that, in the case of facing shocks, bonding social capital is very important, providing emotional support to go further in decision-making. For example, when their business faced the milk price shock in 2015, they endured the shock with the help of the emotional support they obtained from their bonding network. This support gave them the motivation to withstand and re-budget the business. In addition, to cope with the situation, they needed the linking social capital to obtain financial support from the bank. Moreover, the role of bridging social capital was of medium importance, helping with the re-budgeting process.

Case 4 are a middle-aged couple who are owner-operators with an irrigated farm. They are planning to make a stocking rate change to reduce nitrate leaching in a region where this is a problem. The couple are outgoing and work on expanding their networks. They rated bridging social capital of high importance while bonding and linking social capital was of medium importance. Case 4 stated that it was very important for them to keep their management practices up to date and their bridging social capital played an important role in this.

Reliance on bonding, bridging, and linking social capital is also seen in the membership of discussion groups, different groups, and other social networks (Table 4.7). Moreover, when

they were asked how they distinguished their networks, cases 1, 3, and 4 responded with the phrase that they have “many”, while case 2 responded that they have “some”. All the cases stated that their emotional support is primarily provided by their spouse, which is a result of a strong bond between the couples. One of the benefits of social capital is gaining information that helps in attaining different goals (Sandefur & Laumann, 1998). Information flows smoothly through weak ties (Poortinga, 2012). Therefore, bridging social capital is one of the common channels that provide information (Erickson, 2011). Information from consultants and advisors is often used by cases 3, and 4, while cases 1 and 2 only use them occasionally when they are in a special situation. Case 1, 3, and 4 revealed that discussion groups are a useful information source for them, however, case 2, does not use them. All four cases made limited use of academics as a source of information. For example, case 2 stated that he is more cautious about academics, and he thinks that their advice is not practical. The Internet is another source of information used by farmers (Quan-Haase & Wellman, 2004). All four cases use the Internet as a source of information. The Internet is used as a more frequent source of information than the other sources listed in Table 4.7. Moreover, newspapers, magazines and mass media are rarely used by the cases to obtain useful information when they are faced with a disturbance.

4.2.6 Summary of case farms’ capitals

The important characteristics of the case farms and farmers were presented in this section and important similarities and differences were highlighted. The five capitals of the cases is compared in Table 4.8[15]. The natural capital elements for the case farmers shows that case 1 has a higher natural capital compared to the other three cases (Table 4.3). This is because case 1 is in a benign climatic region that has limited climatic variability and a high rainfall. The soils on the farm have medium natural soil fertility and good natural drainage, it is at a moderate altitude and the farm is 95% flat. Case 2 has a medium natural capital because they are in variable weather region that has moderate climate variability and a high rainfall. The soils on the farm have high natural soil fertility and medium-low natural drainage, it is at a low altitude and the farm is flat. Case 3 also has a medium natural capital because they are in a variable weather region that has moderate climatic variability with a high rainfall

[15] The assessment is made by the researcher.

and a high natural drainage. The natural soil fertility is medium and because of the soil type and rainfall and being located in a sensitive catchment they have a nitrate leaching issue. The farm is at a moderate altitude, and it comprises of terraced flats. In contrast to the three cases, case 4 has low natural capital because they are in the region that has low climate variability and low rainfall which means that it could not farm dairy cows without irrigation. The soils on the farm have low natural soil fertility and high natural drainage, it is at a moderate altitude and the farm is flat.

Table 4.8: The five capitals for the four case farms

Capitals	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Natural capital	High	Medium	Medium	Low
Physical capital	Medium-High	Medium-High	Low-Medium	High
Financial capital	Medium-High	Medium-High	Medium	High
Human capital	Medium-High	Medium	Medium	High
Social capital	Medium	Low	High	Medium-high

The physical capital information for the case farms demonstrates the items that the case farmers have invested in to help them improve business performance (Table 4.4). For case 1, physical capital is medium to high. It scored high for improved soil fertility (optimum Olsen P and pH levels), and it has a feed pad and a 40-bale rotary shed, the herd has a medium level of genetics but produces well (497 kg MS/cow). It only has a small runoff but scored high for pasture production 14,200 (kg/DM/ha/year). Case 2 was scored medium for physical capital because it has sub-optimal Olsen P levels, and an optimum soil pH. The farm is tile and mole drained but does not have a feed pad despite having poorly drained soils. It has a herringbone shed rather than a rotary shed, but this reflects farm size. The herd has no genetic records, but they are high producing (500 kg MS/cow). The farm has a small runoff, but it scored high for pasture production 12,000 – 14,000 (kg/DM/ha/year). For case 3, its physical capital is medium to low. Olsen P levels are medium. Although cow numbers, breed, and BW/PW are high, infrastructure items were scored low because of a herringbone shed despite the farm size and the effluent system that needs upgrading. They also produce a low level of pasture production per annum 9,500 (kg/DM/ha/year). Physical capital items for case 4 are all at a high level.

The financial capital for the case farmers, regarding the elements mentioned in Table 4.5, shows that case 1 has medium to high financial capital. Case 2's financial indicators are similar to case 1, but scale has a negative influence here as shown by the total net income per annum figure. As such, it is scored medium for financial capital. Case 3 is a sharemilker and the indicators in Table 4.5 demonstrate differences between case 3 and the other three owner-operator cases reflecting in part that they only receive half the milk income because of the share milking agreement. However, case 3 has scale and this compensates somewhat for the lower financial performance per hectare as reflected in the farm's total net income per annum. As such, the farm was scored medium for financial capital. In contrast with these three cases, case 4 has a high level of financial capital as reflected in the majority of the indicators. The debt level of case 4 is higher than cases 2 and 3, but because the other financial indicators are high and the farm has considerable scale, this level of debt is not a problem.

The human capital for case 1 is medium to high. For case 1 both partners have a degree, and the male partner has an agricultural degree. They also have the most farming experience of any of the cases. Labour availability is medium in terms of cows per FTE (164 cows/EFT). The human capital for case 2 is medium. Both partners only have a high school education but have 26 and 17 years of dairy farming experience. Labour availability is high for case 2 (90 cows/EFT). The human capital for case 3 is also medium. The partners have degrees in agriculture and agribusiness & business respectively but have limited farming experience. combined with 13 and 6 years of dairy farming experience and a low quantity of labour (220 cows/EFT). Case 4 has a high level of human capital as both partners have tertiary qualification in agriculture, considerable farming experience and a medium level of labour availability (162 cows/EFT).

The social capital for case 1 is medium to high. They rely on bonding capital for important decisions more than bridging and linking social capital. They belong to a number of groups and social networks and describe their networks as many. They seek some advice from a range of sources of information. In addition, due to their age and the stability of the farm business, they are somehow active in building a wide range of networks Case 2 has low social capital in terms of the number and range of people they interact with. They do not use bonding, bridging and social capital a lot when they make important decisions and tend

to be reasonably self-contained. They have a small number of networks made up of a few trusted people and occasionally seek outside advice. The couple both believe that a small number of trustworthy people are worth more than a large number of poorer quality people. As a result, they are not active at building large networks. Case 3 has a high level of social capital. They rely on bonding and linking social capital when making important decisions and the latter reflects that the farm is in a sensitive catchment and work with the regional council in relation to nitrogen leaching. In addition, case 3 actively builds networks and are involved with a number of groups, often in leadership positions. They describe their networks as many, and actively seek outside advice. The social capital for case 4 is also high. They rely on bridging social capital for important decisions more than bonding or bridging social capital. They are involved in a number of professional groups, but not social groups. They describe their networks as many, and actively seek outside advice "to help their business".

Some of the network information reflects the case farmers' situation. For example, case 3 has an environmental problem, so actively is linking with the regional council while the other cases are not in the same situation. Social capital data, also, shows where people focus their networks e.g., other farmers and family, rural professionals, regional councils. Moreover, the data reflects knowledge demands of the farm, for example, case 4 is running a high performing irrigated farm, so they needs good quality information from a range of rural professionals to run this. Social capital is complicated to measure since measuring the quality of one's networks is not easy. Quantity may indicate the range of people they are in contact with, but not the quality of the advice they get from these people. A case farmer could be in contact with an average farmer or one of the top farmers in the district. Case 2 is an example of a case farmer who has a small number of experts he relies on, but he believes these people provide very good advice. All four case farmers rely on their partners for their main emotional support. This section has provided a description of the four cases and their respective capitals. The next section describes the results from the cross-case analysis.

4.3 The cross-case analysis results

In this section, the results from the cross-case analysis are presented. Firstly, the disturbances faced by the four case farmers are described and compared in the following

sections. The reasons for any differences or similarities between cases are explained drawing on the characteristics of each case. The case farmers have experienced a number of disturbances over the last 5 – 10 years and these can be classified as shocks or stresses. Shocks are sudden disturbances that interrupt the business and can have irreversible or temporary effects on the functions of a farming system (Meuwissen et al., 2019). In contrast, stresses are ongoing pressures that happen as a result of gradual changes in the system's environment over a long period of time (Alpass et al., 2004; Meuwissen et al., 2019). To understand the case farmers' adaptive capacity, it is important to identify the changes or disturbances in the environment that they have identified and the responses they have put in place to cope with these disturbances. The disturbances were considered from an internal and external perspective. The following sections compare the shocks and stresses faced by the four case farmers.

4.3.1 The shocks faced by the case farmers

In all four cases, the farmers have experienced shocks, both external and internal in nature over the past 5 – 10 years. The external and internal shocks faced by the case farmers are compared in the following sections.

4.3.1.1 The external shocks faced by the case farmers

External shocks are those exogenous sudden changes to the farm business such as a sudden unpredictable drop in product prices, a sudden and unpredictable spike in the price for inputs, or extreme weather events (e.g. droughts and floods) that require agile management decisions to buffer the shock (Darnhofer et al., 2016; Meuwissen et al., 2019). The four case farmers were asked about the external shocks they have faced over the last 5 to 10 years. They had all experienced just one major external shock during this period and this was a sudden, unpredictable drop in global milk price.

The shock faced by the case farmers occurred when milk prices dropped from a high of $8.47/kg MS in 2013-2014 season to very low levels (e.g. $4.69- $4.30/kg MS) for two years in 2015-2016 (DairyNZ, 2020b) in a period when milk prices were normally expected to be around $6.00 - $6.50/kg MS. This shock had a large negative impact on dairy farm businesses across New Zealand and in particular those businesses with a low level of financial capital such as 50-50 sharemilkers (Schroer-Merker & Tozer, 2019). This shock

placed cases 1, 2, and 3 in a difficult financial situation. It was also difficult for case 4, however, they had good debt management before the shock which limited the impact of the shock compared to the other case farmers. Case 4 also had a strong balance sheet going into the shock, thus although they considered the period of low milk prices as a shock, they did mention that it was not that difficult to manage. Case 4 stated that:

> *"It was a big shock, [however] we just made management decisions [since having a strong balance sheet going into the shock] and we put ourselves in quite a strong position going into those two years which a lot of farmers hadn't". (Case 4)*

In contrast, the shock was particularly traumatic for case 3 who is a 50-50 sharemilker. He stated that:

> *"…So, yeah that sort of being burnt into my memory for a long time… I will never forget the 7th of August and we were one week into the calving and the payout drops through the bloody floor, just I'll never forget that feeling". (Case 3)*

In the same way, case 2 described the milk price shock as a difficult time, but not as traumatic as it was for case 3.

> *"… this last particular year was just crap, two years in a row both those years were horrendously low payouts…" (Case 2)*

Similarly, case 1 mentioned that it was the biggest problem they had faced with their business in recent times. The difference in the case farmers' emotional responses to the milk price shock and their ability to cope with it reflects in part the farm and farmers' characteristics and in particular, their portfolio of capitals. This will be described in more detail in section 4.4 where the case farmers' ability to use their different capitals to manage external shocks are compared and contrasted.

4.3.1.2 The internal shocks faced by the case farmers

Internal shocks are those sudden changes in the farm business such as weed or animal diseases or illness or death of the people working on the farm (Crawford et al., 2007a; Meuwissen et al., 2019). These sudden changes also require agile management decisions to buffer the shock (Darnhofer et al., 2016). Table 4.9 shows the internal shocks faced by the four case farmers. Not all the case farmers faced internal shocks. Over the last 5 – 10 years,

only cases 1 and 3 have faced internal shocks. Case 1 had internal shocks to do with a sudden loss of staff members and for case 3, the internal shock was due to a major weed infestation. Case farmers 2 and 4 did not have any internal shocks over the last 5- 10 years.

Table 4.9: A comparison of the internal shocks faced by the case farmers

Internal shocks	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Sudden loss of staff	Yes	No	No	No
The sudden death of a staff member	Yes	No	No	No
The sudden resignation of a staff member	Yes	No	No	No
Major weed infestation	No	No	Yes	No

The internal shock faced by case 1 was due to the sudden loss of staff. In this case, one of his workers died and her husband, who also worked on the farm, left his job soon after, as a consequence of this. These staff made up the entire workforce on the farm, so this was a major shock to the business.

> *"The lady died on the farm, it was a big shock… the husband left and didn't come back again when his wife died". (Case 1)*

Case farmer 3 had a major weed problem that took two years to bring under control. To cope with this problem, they had to employ additional staff for two seasons to control the problem and as a consequence, labour costs increased significantly over this period.

> *"We had a horrific weed problem like a capital weed problem that you know two seasons here we employed two if not three university students and for 8 hours a day". (Case 3)*

How cases 1 and 3 responded to and coped with these internal shocks will be described in more detail in section 4.4 where the case farmers' ability to use their different capitals to manage internal shocks are compared and contrasted.

4.3.2 The stresses faced by the case farmers

Stresses are ongoing pressures that occur over the long term that impose stress and costs on farmers. In this section, the stresses are separated into either external or internal stresses that the case farmers have faced in the past or expect to face in the future. These stresses are discussed in the following sections.

4.3.2.1 The external stresses faced by the case farmers

There have been four different external stresses that the case farmers faced in the last 5 to 10 years of dairy farming. These external stresses are listed in Table 4.10. Cases 2 and 3 highlighted weather variation as an important stress that they faced, but cases 1 and 4 did not. These differences reflected diversity in natural and physical capital across the four farms. In terms of natural capital, case 1 was in a region with a benign climate and good, reliable summer rainfall, whereas cases 2 and 3 were in regions with a variable weather, particularly in relation to summer rainfall. Similarly, case 4, although in a dry climate, had irrigation across the entire farms (physical capital) so that variable rainfall was not a problem. In contrast, cases 2 and 3 did not have irrigation. Case 2 mentioned the variation in weather recently in the following quote.

> *"[When you ask about stress] I hate to say weather, but the weather was the biggest stress so very, very, very wet for a year and a half. And then within 10 days being the driest I've ever seen in my life… It just was unreal. I've never seen anything like that… We can't manage this, so we just buy feed". (Case 2)*

Similarly, case 3 farms in the Wairarapa which has variable weather and a pasture deficit over the summer. As with case 2, they had experienced a very dry summer recently.

> *"Then we had a dry period in November, where we went all right and then it tipped over the other way and went too dry in December, we were back in deficit again. That's why for 18 months we harvested no surplus. Where historically we will take 60-70 tonnes of dry matter off in surplus every year for that 18 months we took nothing". (Case 3)*

Table 4.10: A comparison of the external stresses faced by the case farmers

External stresses	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Weather variation	No	Yes	Yes	No
On-going change in regulations	Yes	Yes	Yes	Yes
The minimum wage (that increases the cost of hiring labour)	No	No	Yes	No
Labour availability (that increases the workload for family)	Yes	Yes	Yes	No

The other external stresses faced by all four cases was the change in government regulations. The changes in government regulations are viewed as a stress by some of the case farmers as a consequence of the nature of their portfolio of natural capital. Farm location was another factor linked to their natural capital. For example, case 3 has free-draining soils and farms in a high rainfall zone that results in high levels of nitrate leaching. These natural capital elements places the farm in a sensitive catchment where the regional council is focusing on improving water quality and regulating farmers to reduce their nitrogen leaching levels. This puts pressure on case 3 to change farming practices. Cases 3 must provide the records that show what their stocking rates is, what bought-in feed they purchased, how much nitrogen they applied, when it was applied, and so on. These regulations are also placing gradual pressure on the farm to reduce its stocking rate. Likewise, case 4 has a nitrate leaching problem, however, they are not in high rainfall region and their irrigation system can be used to manage nitrate leaching to some extent. However, they are also going to face pressure from their regional council to reduce their stocking rate.

Likewise, the portfolio of physical capital has also influenced farmers' perceptions of stresses due to environmental regulations. For example, case 3 has inadequate effluent storage and this makes them more vulnerable to environmental regulations. Also, case 2 mentioned regulations as a stress that adds to the cost structure of their business. This is a general view held by all cases and the farmers mentioned the costs associated with compliance.

> *"Maybe not it's [regulations] probably not forced our profits down, but it is possible to put an added cost into the business, which is unavoidable. So, although I think most of the time a regulation comes in, the cost of it's not enough to affect your profit seriously, but it does affect the cost structure continuously". (Case 2)*

Although case 1 has not been directly impacted on by regulations, and some of this reflects the region that they are in, they know that the on-going changes in regulations will place restrictions on a number of their farming activities. All cases are aware that with the changes in environmental regulations they must adapt their business model to meet the regulations.

Case 3 identified that another external stress for them is the government policy that increased the minimum wage for labour. The minimum wage is important because labour costs make up the highest proportion of operating expenditure for 50-50 sharemilkers and it is the second highest for owner-operators (DairyNZ, 2020a). An increase in the minimum wage increases the cost of hiring labour and reduces the profitability of the farm business for case 3. They are a large-scale farm and as result, must employ labour. This is clear when cows milked per FTE for case 3 is 220, much higher than the other three cases. In this vein, case 1 is a medium scale farm which is financially stable and their concerns about labour are more in relation to labour availability. Case 2 is a small family farm and family labour is adequate to meet the bulk of the labour requirements of the business. They do employ relief milkers so that they can obtain time off the farm. Compared to these three cases, Case 4 did not view the minimum wage regulation and labour availability as stresses since they are obtaining benefits from scale and have adequate labour (162 cows/FTE).

Case 1 and 3 need labour in general, however, they complained about the availability of good workers. For example, case 3 stated that:

> *"…guys haven't been able to last. Guys have been having mental health things; one guy got a nasty concussion. One guy came in that said I'm probably going to university and subsequently has. The current guy that's just about to leave, his partner is pregnant with their second child but she's missing family and he's heading over back over the Manawatu every day because she's missing her family and it's you know what I mean it's that sort of stuff" (Case 3)*

The next section is about the internal stresses for the case farmers.

4.3.2.2 The internal stresses faced by the case farmers

Internal stresses are ongoing internal disturbances or changes that are not from outside and relate to the business itself (Meuwissen et al., 2019). These internal stresses are either stresses that the farmers have experienced in the past or expect to experience in the future. For the case farmers, internal stresses were mostly about the future which included the increased cost of hired labour, a high family workload, and the need by the sharemilkers to maintain their reputation as good farm managers (Table 4.11). The first two stress are entwined with the aforementioned external stresses.

Table 4.11: A comparison of the internal stresses faced by the case farmers

Internal stresses	**Case 1**	**Case 2**	**Case 3**	**Case 4**
The increased cost of hired labour (Consequence of higher minimum wage)	No	No	Yes	No
High family workload (Consequence of labour availability)	Yes	Yes	Yes	No
The need to maintain a good reputation	No	No	Yes	No

The increased cost of hired labour is a consequence of the external stress of increases in the minimum wage level over time. A recent increase in the minimum wage level has increased case 3's wage bill for the coming years. Since labour is the largest operating cost to the business, this cost is an ongoing stress for them primarily because they have a high level of debt (60%) and a low level of net income per hectare. In contrast, the other cases have much lower levels of debt and much higher levels of net income per hectare and as a result, they do not perceive an increase in labour costs as a stress. As such, this stress reflects case 3's financial capital relative to the other case farms.

The internal stress of a high workload for the family was identified by cases 1, 2 and 3. Case 1 mentioned that their children are grown up and have left home. Previously the children helped out on the farm, but now they do not have this labour contribution from their children, and they must do the work themselves. They do employ staff, but find that the staff have limited capability, and this increases their workload, particularly over calving. For case 2, the couple are the primary labour on the farm. This is because the farm is not large enough to hire a full-time staff member. As such, the couple perform most of the work with some assistance from relief milkers that allows them to take time off during weekends and for holidays. The workload for the couple is not very high compared to cases 1 and 3 (see Table 4.6), however, case 2 mentioned that this is a source of stress for them, particularly if one of them falls sick. Case 3 also mentioned the high workload as a stress they faced. To reduce this stress, they employ a full-time staff member, but they have struggled to find reliable staff over the past three years. This struggle links to labour availability and quality. The workload was not identified as stress for case 4 because the scale of the farm allows them to employ sufficient labour to provide them with a good work-life balance.

The high family workload can be considered from the farm-scale viewpoint. Farm scale has two effects; small farms cannot afford full-time staff, so must rely on relief milkers and

casual staff, and also contractors to reduce the workload. Larger farms must employ labour. Problems occur due to labour availability and quality, where farmers cannot hire good quality staff, and as a consequence, they end up doing the work themselves. In terms of scale effects, a small farm like case 2 cannot afford to hire permanent labour, whereas a very large farm like case 4 employs 14 non-family staff plus 2 family staff members.

The other internal stress identified by case 3, is the stress they feel in terms of maintaining their reputation as good farm managers. Case 3 is a 50-50 sharemilker and they said their long-term plan is farm ownership. To do this, they need to demonstrate that they can manage a farm well and achieve good physical and financial performance which then gives them a good reputation as sharemilkers. The other three cases that own their own farms do not have the stress faced by case 3. To cope with external and internal stresses, the case farmers have had to adapt their management. This is discussed in section 4.5. The following section describes the case farmers' perceptions of their capitals in relation to their ability to cope with the shocks.

4.4 The role of capitals in the management of shocks

When the case farmers were asked about the impact of the shocks on their business, they commented on the management practices that they used to cope with the shocks. This section explores the case farmers' perceptions of their dependence on the different capitals when they were faced with a shock (internal or external) during the past 5 to 10 years. Different capitals are important for different shocks and they can also vary between farmers. Table 4.12 shows the shocks that the farmers have dealt with over the last 5 - 10 years.

All four farmers had faced a shock caused by a drop in milk price over the period 2015-2016. They were exposed to this external shock because there was a fall in global milk prices due to excess supply and lower demand in the international dairy market (DairyNZ, 2019). Other external shocks that can impact on dairy farmers in New Zealand include floods, droughts, input price shocks, and sudden changes in regulations. However, the four cases in this study had not experienced these shocks during the last 5 – 10 years. For the internal shocks, the shocks experienced by the case farmers included a loss of staff by case 1 and a weed problem for case 3.

Table 4.12: External and internal shocks faced by the case farmers

Shocks		**Case 1**	**Case 2**	**Case 3**	**Case 4**
External	Milk price drop	Yes	Yes	Yes	Yes
Internal	A weed problem	No	No	Yes	No
	Sudden loss of staff	Yes	No	No	No

The case farmers identified the capitals that they thought were important for coping with a drop in milk price and these are shown in Table 4.13. The most important capital identified by the four case farmers for coping with the shock was their financial capital. For example, cases 1, 2, and 3 mentioned that they utilised over-draft facilities to manage the shock. However, case 4 stated that they were proactive in managing upside risk when the milk price was high and had paid off debt to put the farm in a stronger financial position. This allowed them to cope with the milk price shock because debt repayments were at a much lower level for them due to their previous active debt reduction policy.

> *"…the year of the $8.30/kg MS price, it was some payout, we paid off a bit of debt, we were quite proactive in that. And then we also had a bit that we just pushed through as cash flow… We paid off quite a bit of debt and we put ourselves in quite a strong position going for those two years which a lot of farmers hadn't." (Case 4)*

Table 4.13: The capitals that the case farmers considered important for the management of a drop in the global milk price (External shock)

Capital	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Financial	Yes	Yes	Yes	Yes
Human	Yes	Yes	Yes	Yes
Social	Yes	Yes	Yes	-
Physical	-	-	Yes*	-

* They changed their physical capital to cope with the drop in milk price shock

All case farmers mentioned their capabilities to make decisions as influential in the management of the milk price shock. Regarding this, human capital has been identified as important from the decision-making viewpoint because of the attributes of the decision maker [16]. The four cases highlighted different human capital attributes that were important

[16] The attributes of human capital are background, locus of control, self-efficacy, sense-making, strategic thinking, willingness to accept change, and open-mindedness (aforementioned in Chapter 2, Section 2.5.2.3).

for managing the sudden fall in milk price. In addition, their human and social capital were re-enforcing each other. For example, case 1 believes that his dairy farming experiences and his university study has helped him to be a person who could manage that milk price shock. Meanwhile, he also got some advice from close relatives and decided to extend their overdraft. Getting advice was almost the same for case 2, although without help from relatives. Case 3 experienced a difficult time when the price shock occurred, however, he mentioned getting emotional support from family and some friends over this time. In addition, he relied on his own ability to plan a new path to manage the shock. The following quote shows how he sees himself in such a situation:

> *"There is no rhyme or reason to how I came up with it, it just came to me, it was not luck but it's just I suppose it's innately who I am". (Case 3)*

Likewise, case 4 stated that when the shock happened, they were quite proactive and reduced their debt level before the shock, demonstrating the importance of their human capital.

Similarly, social capital had an important role to play in decision-making[17]. Three of the four cases identified social capital as important for managing the milk price shock. This was related to their relationship with their bank which was important in terms of access to funds and extending their overdraft facilities. In this vein, case 1 talked about their good relationship with the bank, which allowed them to borrow more money during the period of low milk prices in order to maintain their liquidity. He makes this point in the following quote:

> *"In terms of the milk price downturn, we were able to borrow money from the banker. So, we have to try to maintain a good relationship with our bankers…[however] there is stress seeing your overdraft going up and up". (Case 1)*

The other important aspect of social capital for cases 1, 2, and 3 was the emotional support they obtained from their wives, close relatives, or some friends to cope with this sudden fall in the milk price. Case 4 did not identify social capital as important in relation to coping with the milk price shock. This was because the farm was in a good financial position, and they

[17] Social capital aspects are around the value of trustworthy people, information source, community Involvement, bonding, bridging, and linking (aforementioned in Chapter 2, Section 2.5.2.4).

did not need assistance from their bank or need any emotional support during the shock. As mentioned in Section 4.3.1.1, the shock was most traumatic for case 3 compared to the others. Therefore, case 3 used their social capital, to access information and advice to a great degree than cases 1 and 2. Case 3 used their networks to develop a plan to cope with the low milk price when they talked to their advisor and accountant to obtain advice. The development of case 3's plan required some major changes to their business structure including the physical capital. For example, they implemented changes in their physical capital to cope with the shock. It was the potential of physical capital that enabled them to go for core replacements buying extra cows and selling all dry cows. They increased the herd size from 400 to 440 cows and reduced staff numbers by one full-time equivalent. To cope with the higher labour requirements, case 3 placed half the herd on once-a-day milking from early October. Therefore, case 3 utilised a mixture of human, social, and financial capital. He believes that "necessity is the mother of all invention" and the following quote shows his agility to respond to the shock.

> *"So, Friday we had the payout drop, by Sunday I fired out in an email that went to the Board of Directors of the farm and went out to our Board of Advisors and said this is the plan, this is the numbers, this is how it going to work. Overdraft is going to blow out to something historically scary what does everybody think? And within a week we had a green light from all the stakeholders in all businesses that said just go and get on with it". (Case 3)*

Facing the same shock, cases 1 and 2 also mentioned their reliance on human, social, and financial capital. Both cases 3 and 4 highlighted their decision-making ability (related to their human capital) to cope with the shock. In addition, case 4 explained that a combination of their decision-making skills (human capital), their low-cost structure or farm working expenses (financial performance related to financial capital), and a good cash flow (financial capital) put them in a strong on-going position to cope with the two low-milk price years (2015-2016).

Over the last 10 years, the case farmers had faced limited internal shocks. Case 1 had a sudden loss of staff without warning and had to cope with this. Case 3 had a major weed problem that occurred over two seasons. No internal shocks were reported by cases 2 and 4. The capitals that were important for coping with the internal shocks are shown in Table 4.14.

Table 4.14: The capitals that the case farmers considered important for the management of reported internal shocks

Capital	Case 1	Case 2	Case 3	Case 4
Financial	Yes	No	Yes	No
Social	Yes	No	Yes	No
Human	Yes	No	Yes	No

Case 1 stated that encountering an internal shock due to the sudden loss of staff required them to draw on their social capital and make arrangements with a neighbour to run the farm for six months. This was because they were not available to run the farm themselves at that time. This gave them time to consider different management options for the property. They decided to sell the farm and buy another one closer to where they were already farming and living so that it was convenient for them to manage. The neighbour's willingness to help in a difficult situation demonstrated the importance of the bonding social capital that existed between case 1 and the neighbour to cope with this shock. Their human capital in relation to decision-making and their financial capital in terms of the equity they held in that farm allowed them to make this change and purchase a nearby farm.

Case 3 faced an internal shock due to a major weed problem that reduced both pasture quality and production on the farm. He stated that because they did not have sufficient labour (quantity of human capital) on the farm, they had to employ three university students for eight hours a day over two years to control the weed problem. This resulted in a large wage bill for case 3, demonstrating that case 3 was able to utilise their financial capital to employ labour to manage the weed infestation. In addition, he needed social capital for advice on how to remove it and he also needed to tell the students what to do to remove the weed.

For the four cases, the capitals were utilised to differing degrees in order to manage the external and internal shocks they faced. Also, the farmers' decision-making ability (as a part of human capital) was important to utilise other capitals to manage the shocks. The following section is about the role of the five capitals in the management of stresses.

4.5 The role of capitals in the management of stresses

When the case farmers were asked about the impact of stresses on their business, they commented on the management practices that they used to cope with these stresses. The farmers identified the different capitals that were important for coping with different stresses and the results showed that these vary between farmers faced with the same stress. Table 4.15 shows the stresses that the farmers have dealt with over the last 5 to 10 years or expecting to face in upcoming years. Four external stresses were identified by the case farmers: weather variation, on-going changes in environmental regulations, increase in the minimum wage, and labour availability. Three internal stresses were identified by the case farmers: the increased cost of hired labour, the high workload for the family, and The need to maintain a good reputation.

Table 4.15: External and internal stresses faced by the case farmers

Stresses		**Case 1**	**Case 2**	**Case 3**	**Case 4**
External	Weather variation	No	Yes	Yes	No
	On-going change in environmental regulations	Yes	Yes	Yes	Yes
	Increase in the minimum wage (that increases the cost of hiring labour)	No	No	Yes	No
	Labour availability (that increases the workload for family)	Yes	Yes	Yes	No
Internal	The increased cost of hired labour	No	No	Yes	No
	The high workload for the family	Yes	Yes	Yes	No
	The need to maintain a good reputation	No	No	Yes	No

Table 4.16 shows the capitals that the case farmers believed were important for managing these stresses. Cases 2 and 3 identified variations in the weather as an important external stress. They utilise human, financial, and social capital to help cope with the stresses due to variations in weather.

Table 4.16: The capitals that the case farmers considered important for the management of variation in weather

Capital	Case 1	Case 2	Case 3	Case 4
Financial	No	Yes	Yes	No
Human	No	Yes	Yes	No
Social	No	Yes	Yes	No
Physical	No	Yes	Yes	No

Cases 2 and 3 both use once-a-day milking (Human capital) and bought-in feed (Physical capital) that increased their costs affecting their financial capital to cope with dry summers. They both stated the importance of a good relationship with feed providers to ensure they can source feed when required (Social capital). This is illustrated by the following quote from case 3:

> *"I rang up our silage contractor and said we still need 100 tonne silage which traditionally comes in December. I said we can't pay our bill till January how do you feel about that. He said if your farm pays their half, we'll spread the payments for three months for you and you can pay it to the end of April. And we can have that relationship being up front and nice with everybody". (Case 3)*

Case 3 also uses wet soil management (Human capital) during wet winters to reduce pugging damage (See the following quote). He also relies on physical capital in the form of a feed pad to minimise the impact of wet winters on soil structure. Investment in infrastructure was required to set up the feed pad (Financial capital) and case 3 also bought-in feed to feed the herd when they were on the pad, so financial capital was also important in managing this stress.

> *"Our topsoil is probably about 4 inches thick. But it acts like peat, peat when it gets wet swells up and it loses all its structure it just turns to slop. And we get through June/July that sort of period if we get more than 15 ml of rain and we've got the cows held uptight you've got to be proactive. we got to stand them off from the feed pad or sacrifice areas or whatever and we've got to get them off". (Case 3)*

All four case farmers identified changes in regional environmental regulations as another important stress that they have faced and are facing going into the future. This external stress is portrayed through the different kinds of consents farmers need to obtain to

continue farming. In terms of the capitals that the case farmers thought was most important for managing this stress, all four cases considered that human and financial capital were important (Table 4.17).

Table 4.17: The capitals that the case farmers considered important for the management of changes in environmental regulations

Capital	Case 1	Case 2	Case 3	Case 4
Human	Yes	Yes	Yes	Yes
Financial	Yes	Yes	Yes	Yes
Physical	-	Yes	Yes	Yes
Natural	-	-	Yes	Yes
Social	-	-	Yes	-

All four case farmers stated that human capital is required to decide the best way to manage this stress via the need to invest in items of physical capital or natural capital conservation. For example, case 1 used his decision-making process to identify low cost options that would meet the environmental regulations. Case 2 decided to obtain an effluent consent that allows them to carry higher cow numbers than they currently have to future proof against changes in regulations. Case 3 mentioned being located in a sensitive catchment region and how their decision making is important to meet the environmental regulations. They have also developed a plan B to change farming region if it becomes too difficult to cope with the regulations in a sensitive catchment. As a sharemilker, it is simpler for them to change farming location because they do not own the land.

Interestingly, only case 3 considered that social capital was important for managing the stress related to changes in regulations. This is because they need to be more attentive to regulations because of their location in a sensitive catchment, than the other three cases. In this vein, they have expanded their linking social capital to obtain more information and support from staff at the regional council.

Case 3 identified the minimum wage as external stress which causes the internal stress of an increased cost of hired labour. To cope with this stress, they themselves need to work more than they otherwise would drawing on their human capital (Table 4.18), which impacts their

work-life balance. Table 4.18 shows the capital's importance for managing the minimum wage regulation.

Table 4.18: The capital that the case farmer 3 considered important for the management of changes in the minimum wage

Capital	Case 1	Case 2	Case 3	Case 4
Human	-	-	Yes	-

Labour availability is a stress identified by cases 1, 2, and 3. Where case 3 has to tolerate a high workload in different periods to cope with this stress, cases 1 and 2 are concerned about finding reliable seasonal labour or a relief milker. Therefore, human capital is the only important capital for the management of the labour availability stress (Table 4.19).

Table 4.19: The capital that the case farmers considered important for the management of labour availability

Capital	Case 1	Case 2	Case 3	Case 4
Human	Yes	Yes	Yes	-

Case 3 identified an internal stress in relation to the need to maintain a good reputation. They are 50-50 sharemilkers and to grow their business and move to larger farms they need to maintain a good reputation in the industry. They must grow their business to meet their long-term goal of farm ownership. To overcome this stress, they are relying on their human capital portrayed by their ability to think strategically and to plan (Table 4.20). They try to work on their skills (human capital) to do financial management and improve the quality and productivity of their herd. In addition, they are actively build social networks and involve themselves in industry events. This social capital (Table 4.20) helps enhance their reputation. The following quote shows case 3's view on managing this stress:

> *"I've also done the Young Farmer of the Year competition two-time grand finalist in that as well. So, sort of that helps your reputation and gets your name out there… that's putting us toward the top of the list in terms of when we put our name out there. Then people are coming to us with proposals, it tells me that we've got a bit of control as to what our opportunities are for us. So, I suppose it gives us the confidence that when we go to people with proposals that we can say this is what we know we can do, how we [as a sharmilker] can deliver a win-win for you guys." (Case 3)*

Table 4.20: The capitals that the case farmer considered important for the management of the stress to do with the need to maintain a good reputation

Capital	Case 1	Case 2	Case 3	Case 4
Human	-	-	Yes	-
Social	-	-	Yes	-

Comparing the four cases in terms of coping with diverse disturbances, illustrates that the case farmers talk about the shocks and stresses, the importance of capitals, and the interaction between capitals, implicitly. For example, in terms of adaptive capacity, if a farmer faces a new situation due to a shock or stress, they must learn how to manage it. Some of them would expect that human capital will be important in all instances. Moreover, social capital is likely to be important as they tend to build new networks to learn about new areas that they have not managed before. Financial capital will be important for investments or for surviving shocks that reduce income sharply. Physical capital such as effluent storage and irrigation, feed pads for wet soils may be important for coping with some types of shocks or stresses. Natural capital is an important determinant of whether or not a problem can be defined as a shock or stress. For example, weather variation is not an issue in a benign climate, nor is nitrate leaching is not a problem in regions that don't have sensitive catchments. Furthermore, it is identified that the capitals a farm has may reduce the importance of a particular disturbance. In this vein, a comparison between case 3 and case 4 is a good example where the milk price drop is a trauma-like shock for case 3, while case 4 can manage it easily. Therefore, the investigation of perceived adaptive capacity dimensions in this chapter brought new insights into the context of dairy farming for New Zealand dairy farmers. These insights then formed the basis for refining the design of the survey instrument used in the quantitative phase of the study. In the following section, the insights that have emerged from the cross-case analysis, that were used to help design the survey instrument, will be discussed.

4.6 Implications for survey design

The qualitative phase of this study played two roles for the researcher. The first was to help the researcher understand the New Zealand dairy farming context since she was an international student. In terms of the second role, because little is known about the adaptive capacity of New Zealand dairy farmers, the case study was used in an exploratory

manner to highlight new insights that would be useful in the design of the survey within the conceptual framework. Designing the survey questions comes from gaps in the literature. Previous subjective measurements of adaptive capacity focused on either the five-capitals framework or the decision-making framework but had not combined these two frameworks together. Also, previous research did not consider the risk or uncertainty confronting the business in the determination of adaptive capacity. The survey questions in the current research were designed to contextualise perceived adaptive capacity in a combined framework accounting for the five capitals and decision-making. Key insights from the interviews have been obtained in terms of 1) the nature of the shocks and stresses faced by the case farmers, 2) the capitals influence the shocks and stresses the case farmers are exposed to, 3) the farmers' perceived importance of the capitals in terms of coping with and managing the shocks and stresses and why these were important.

The qualitative interviews provided some interesting findings in terms of understanding common disturbances for New Zealand's dairy farmers and the classification of these as shocks or stresses, both external and internal. The case study also identified that the portfolio of capitals that a farmer had, influenced their exposure to different stresses and shocks. For example, natural capital of a farm influenced the farmers' exposure to regulatory stresses. A farmer's location, that is whether or not they were in a sensitive catchment or in a region with important environmental issues, made them more exposed to regulatory stresses. Likewise, the rainfall and soil types on a farm influence nitrogen reaching levels and so farmers with these elements of natural capital were more exposed to regulatory stresses. Similarly, a farmer with good financial capital was able to cope with the milk price shock with less effects comparing to other farmers who are not in a good financial situation. Furthermore, the farmers identified that different combinations of capitals are important for the management of different shocks and stresses. Therefore, different shocks and stresses required different capitals. The portfolio of capitals a farmer has influences how they respond to a shock or stress i.e what management strategies they utilise.

While the findings from the qualitative phase indicated insights into the New Zealand dairy farming context, it was necessary to collect quantitative data which could be subjected to design a measurement tool for perceived adaptive capacity. The insights that emerged from the four interviews informed the development of the survey used in the quantitative phase.

The question design was around uncertainties, management practices, and five capitals (natural, physical, financial, human, and social). The survey questions are presented in the next chapter. The qualitative findings also helped with the interpretation of the quantitative results in the discussion chapter.

Chapter 5 : Quantitative results

5.1 Introduction

This chapter reports the survey findings, which were designed to use data from a sample of dairy farmers to develop an index for each farmer's perceived adaptive capacity when facing disturbances. Specifically, the disturbances they were to consider as shocks and stresses. The number of electronic questionnaires emailed to the farmers was 206, from which 109 responses (53%) were received. However, of these, 44 had more than 10% missing data and were excluded from the sample. This left 65 usable survey responses, a 34% response rate from the farmers. The data gathered through the survey were analysed and are presented in this chapter. Firstly, descriptive statistics are presented to provide a context of the sample. Secondly, the sample farmers' perceptions were reported to look deeper into their views around sources of uncertainty, management practices, and five capitals. Thirdly, the data were subjected to two weighting methods: the first, using the proportion of variation explained by each variable using principal component analysis (PCA), and the second, using equal weights (EW). Both weighting methods reduced the dimensions of the data based on: uncertainty, management practices, and the five capitals.

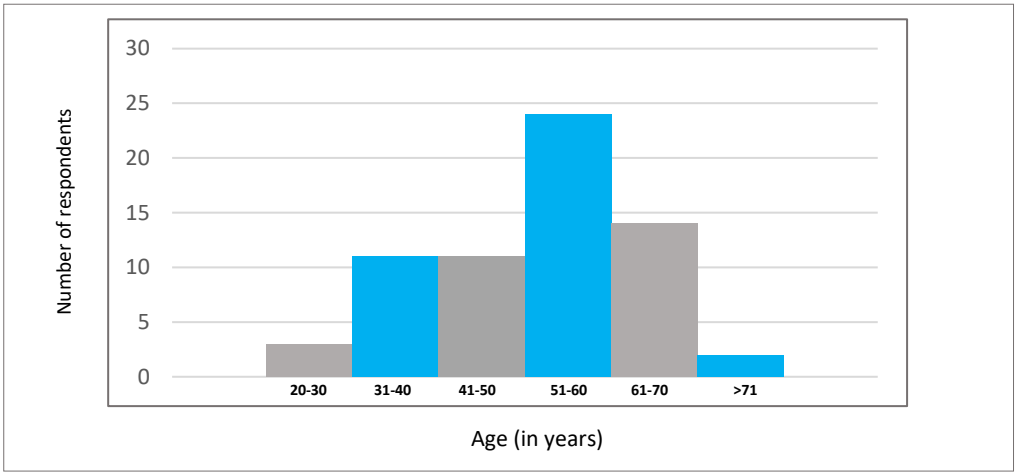
5.2 Farmer and farm characteristics

Presented in this section are the statistics of the sample including farmer demographics and farm characteristics. This provides an overview of the data presented, beginning with farmer characteristics including age, farming experience, education, and ownership. The overview of farm business characteristics also includes the location, stage of the farm business, the farm size, production levels, and personnel involvement.

5.2.1 Farmers' characteristics

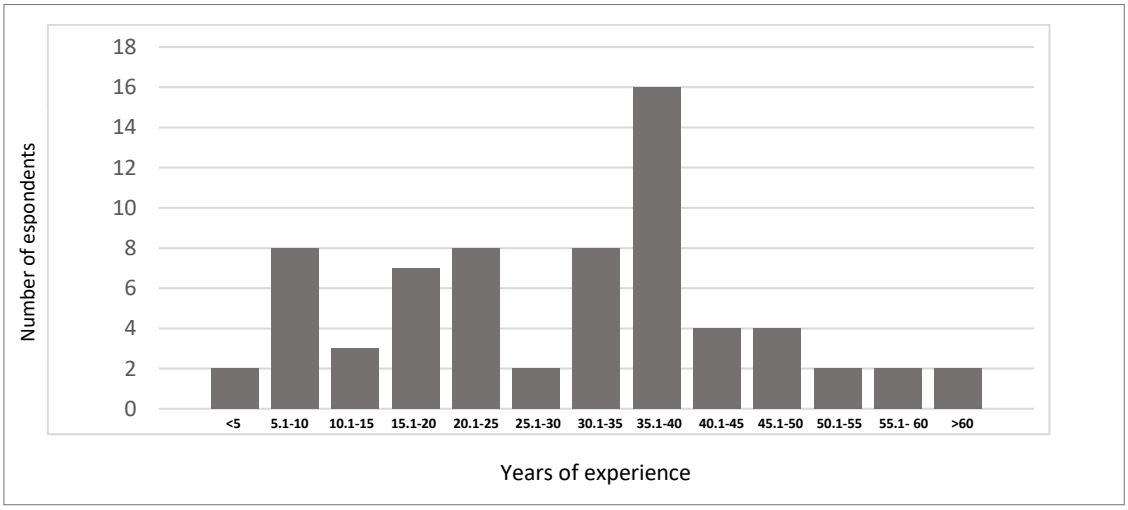
In this survey 62% of respondents are farm owners (including operators and/or non-operators); 17% are equity partners and 21% are 50-50 sharemilkers. Of the total number of 65 respondents, 37% are aged 51-60, 38% are less than 50 years old, and 25% are more than 60 years old (Figure 5.1).

Figure 5.1: Age of sample farmers



The studies by Shadbolt and Olubode-Awosola (2013) and Duranovich (2015) show the average age of New Zealand dairy farmers is 52. Here more than 62% of respondents are at least 51 years old. As Duranovich (2015) said, when the survey targets farm business' decision-makers, it is expected that these farmers will usually be older than 51 years of age. In addition, the respondents of this survey had an average of 33 years of farming experience. The frequency of accumulated farming experience is depicted in Figure 5.2.

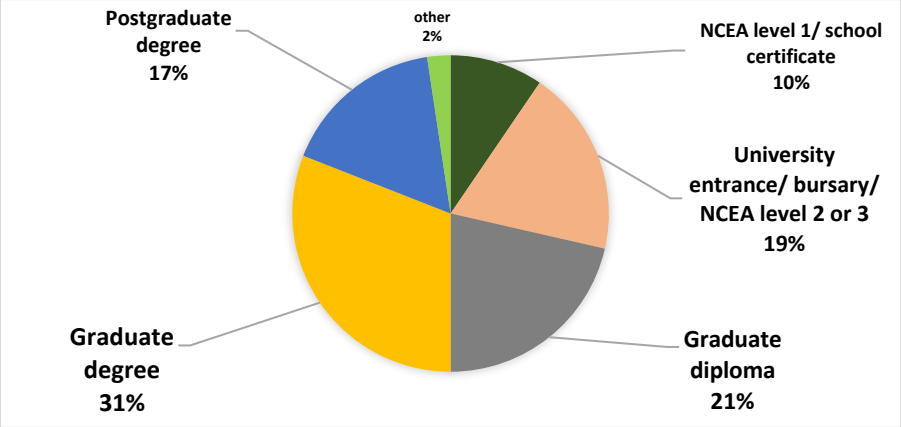
Figure 5.2: Years of farming experience



The respondents' highest level of formal education is presented in Figure 5.3. Almost one-half have a university qualification, with 31% achieving a degree, and a further 17%, a postgraduate qualification. Twenty-one percent have a graduate diploma. Fewer have finished formal education at NCEA level 2 or 3 (19%) and 10% at NCEA level 1. NCEA is New Zealand's National Certificates of Educational Achievement, which are national

qualifications for senior secondary school students. NCEA is recognised by employers and used for selection by universities and polytechnics, both in New Zealand and overseas[18].

Figure 5.3: The highest level of formal education achieved by these farmers



5.2.2 Farm businesses' characteristics

In the survey, six options for stages of the farm business were presented, plus a further option of "other". The farm business stages are shown in Table 5.1. More than half of respondents identified the stage of their farm as "Improving farm performance (while maintaining current size)". The next highest stage was "Entry of next-generation (before exit)" with 14%, while the three stages; 'entry', 'growth by expanding the farm size', and 'consolidation' combined, represented a total 19% of farms. In addition, 12% of participants chose the "other" option, specifying this with different statements such as a mixture of "improving farm performance, entry of next generation, and exit" or "growth of equity through off-farm investment".

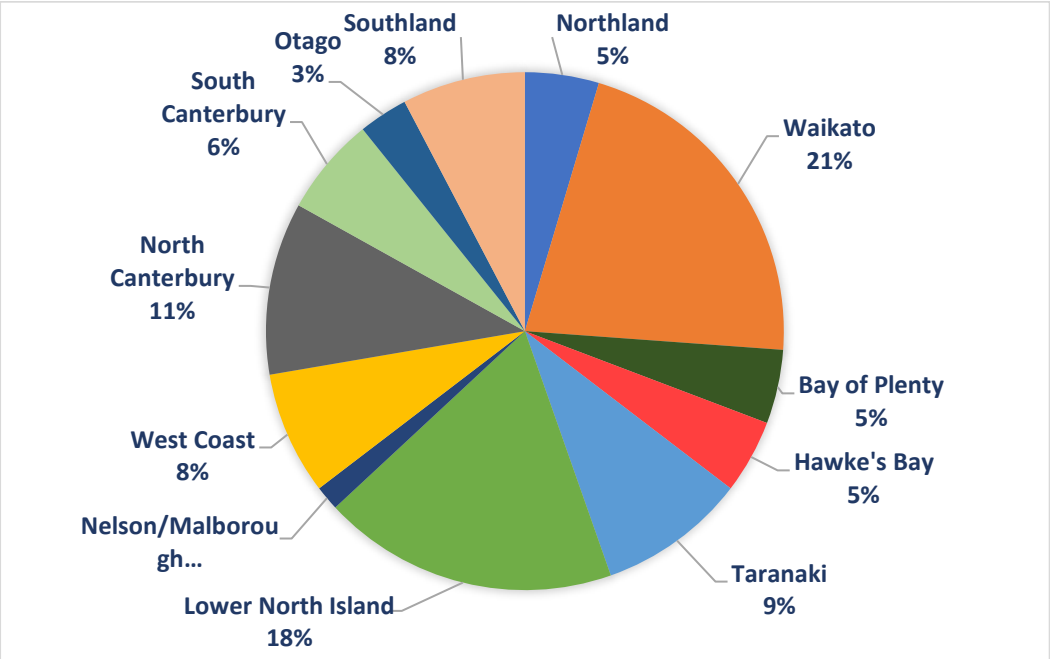
Table 5.1: The stage of the farm business

Improving farm performance (while maintaining current size)	54%
Entry of next generation (before exit)	14%
Other	12%
Growth by expanding the farm size	8%
Consolidation (to maintain my farm as it is)	6%
Entry	5%
Exit	1%

[18] https://www.nzqa.govt.nz/ncea/understanding-ncea/how-ncea-works/

Farm location is another characteristic of the farm business and is presented in Figure 5.4. The largest group of respondents (63%) are from North Island consistent with DairyNZ (2020a) that says the majority of dairy herds (71.4%) are located in the North Island containing 58.1% of all cows milked. The survey respondents have 57.50% of all cows milked in the sample. The greatest concentration in New Zealand situated in the Waikato region. Participated in the survey, Waikato with 21% of the survey from each are the largest groups of respondents. According to DairyNZ (2020a), South Island dairy herds account for 28.6% of the national total containing 41.9% of all cows milked. The survey respondents from South Island are 36% of total respondents a little bit higher than the percentage reported in DairyNZ (2020a) (28.6%). However, all cows milked are 42.5%, of total cow numbers, which is aligned with DairyNZ (2020a).

Figure 5.4: Percentage of the farm businesses in different locations



Presented in Table 5.2 are the statistics for the sample farm businesses. These are the effective milking area, herd size, milk production, stocking rate, production per cow, and production per hectare. The sample shows a good variety of farm sizes, ranging from 65 ha to 475 ha, with a production per hectare (kg MS/ha) from 245 to 1,764 (kg MS/ha). The stocking rate is from 1.6 to 3.9 (cow/ha). The spread range of data is seen. For example, the standard deviation for effective milking area, number of cows milked at peak, and

production per farm business is greater than ½ mean. In addition, the mean of the sample mostly is similar to the New Zealand average.

Table 5.2: Farm size and production levels

Variable	Min.	Max.	Median	Mean	SD	NZ average
Effective milking area (ha)	65	475	170	186	95	155
Number of cows milked at peak	180	1,700	467.5	540	306	440.2
Production per farm business (kg)	63,039	806,078	199,000	216,218	141,411	169,595
Stocking rate (cow/ha)	1.6	3.9	2.9	2.8	0.4	2.8
Production per cow (MS/cow)	210	514	388	392	60	385
Production per effective hectare (kg MS/ha)	245	1,764	1,098	923	348	1,096

5.3 Farmers' perceptions

Presented in this section are the farmers' perceptions of the business environment, perceptions of management practices, and of the five capitals. The perceptions reported, begin with those around the different uncertainties that the farm business may face. The next perceptions are those around a number of recognised management methods of dairy farming in New Zealand. The last is the farmers' perceptions concerning the five capitals of their farm business.

5.3.1 Farmers' perceptions of the business environment

The changes occurring in dairy farming in New Zealand were presented as uncertainties in the survey. The farmers' overall perceptions of each source of uncertainty were calculated as described in section 3.4.1.1. All the results are presented in Tables 5.3 to 5.7. The list of uncertainties drawing upon source of uncertainty used in other studies on risk management for farm business in New Zealand (Duranovich, 2015; Khatami, 2022; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). Table 5.3 presents the respondents' perceptions of possible uncertainties from climate change variation, changes in production, and technological change.

Table 5.3: Farmers' perceptions of climate variation, production, and technological change sources of uncertainty

Source of uncertainty	Number of responses	% of responses			Three-dimensional impact of the uncertainty (% of responses)				
		Opportunity	Threat	Opportunity & threat	Very little	Little	Some	High	Very high
Climate variation	60	13.3	23.3	63.3	1.7	1.7	25.0	60.0	11.6
Changing in pasture/crop/animal health	60	42.4	20.3	37.3	0	5.0	16.7	70.0	8.3
Technological change	59	59.3	1.7	39.0	1.7	3.4	15.3	44.0	35.6

Note: In this and the following tables, of the 65 respondents, most, but not all answered these questions

In Table 5.3 there is evidence that perceived future climate variation presents both opportunity and threat for almost two-thirds of these farmers (63%). Others see it as solely an opportunity (13%), and others solely as a threat (23%). When observing the three-dimensional impact of the uncertainty around climate, the survey shows that 72% of farmers perceive 'climate variation' to have a high or very high impact on their business. Climate change has been introduced as a production risk in previous studies (Duranovich, 2015; Shadbolt & Olubode-Awosola, 2013) for which different strategies can be adopted in accordance with the farmers' perceptions. Since dairy farming in New Zealand is pasture-based and the pasture grown is dependent on the climate; enough rain and enough sunshine. Therefore, it is expected that the climate variation is considered as having a high and very high impact on their business.

Changing pasture/crop/ animal health has been introduced as a production risk in previous studies (Duranovich, 2015), which show the changing conditions of production over time. Changing pasture/crop/animal health is seen as both opportunity and threat for 37%, as solely an opportunity for 42%, and solely as a threat for 20% of farmers. When observing the three-dimensional impact of the uncertainty around pasture/crop/animal health, the survey shows that 78% of farmers perceive it to have a high or very high impact on their business. For example, a disease like Mycoplasma Bovis is an animal health issue that can have a high impact on the business. Moreover, any weed breakout has a high impact on

pasture/crop yield. Therefore, the farmers are aware that pasture/crop/animal health provides an opportunity for their business.

In comparison with climate change and pasture/crop/animal health-related uncertainties, more than half of the farmers think that 'technological change' presents an opportunity for the business and less than 2% perceive it as a threat. When observing the three-dimensional impact of the uncertainty around technological change, the survey shows that 80% of these farmers perceive technological change to have a high or very high impact on their business. Being perceived as an opportunity with a high impact on the business, technological change such as new technologies is an influential factor for the business. Technological change is considerable since it can help to reduce some major dairy operating expenditures. For example, according to the Economic survey (DairyNZ, 2020a), labour is the second rank major expenditure for owner-operators and the first rank major expenditure for sharemilkers. In this vein, utilising bail rotary milking cows instead of aside herringbone is a technology change for a dairy farm that will reduce the time for labour and consequently will reduce its expenditure in dairy operating. Thus, technology change can provide an opportunity to the dairy farm business and can be helpful to reduce dairy operating expenditures. The majority of farmers consider climate change, production inputs' health, and technological change to have potentially high or very high impacts on their business.

The focus of Table 5.4 is on the farmers' perceptions of uncertainty relating to market variability, whether from, say, uncertainties around the milk price through to the reputation and image of the dairy industry.

'Input prices and availability of inputs' are seen as a real threat to the business, with more than two-thirds of the farmers identifying them as a threat. Also, 'global competitors and competition' is ranked second as a perceived threat (42%). When observing the three-dimensional impact of these uncertainties, the survey shows that farmers perceive the impact on their business by 'input prices and availability of inputs' (85%) and the impact on their business of 'global competitors and competition' as high or very high (71%). These two sources of uncertainties are directly related to international trade which is highly important for New Zealand dairy farming. The expanding dairy industry has increased farmers' reliance on inputs from outside the farm such as imported supplements and fuel. Therefore, it is

expected that the farmers rank the price and availability of input first. Moreover, competition in the export of dairy products is extremely important for New Zealand to the dairy industry and dairy farmers[19] because dairy exports are a major driver of New Zealand's terms of trade. Dairy farmers are aware that New Zealand does not have the internal market to consume all dairy products and the dairy industry needs to sell 95% of production as dairy commodities to the global market. Thus, from the dairy farmers' viewpoint, global competitors and competition come as one of the major threats to the business.

Table 5.4: Farmers' perceptions of market-related uncertainties

Source of uncertainty	Number of responses	% of responses			Three-dimensional impact of the uncertainty (% of responses)				
		Opportunity	Threat	Opportunity & threat	Very little	Little	Some	High	Very high
Input prices and availability of inputs	59	1.7	69.5	28.8	3.4	1.7	10.2	54.2	30.5
Global competitors and competition	59	11.9	42.4	45.8	1.7	3.4	23.8	50.8	20.3
Business relationships (with input providers)	57	57.9	7.02	35.1	1.8	3.5	28.1	59.6	7.0
Global supply and demand for food	58	51.7	3.5	44.83	3.4	1.7	15.5	53.5	25.9
Milk price	59	13.6	23.4	62.7	3.4	1.7	35.6	49.2	10.1
Reputation and image of the dairy industry	59	11.9	27.1	61.0	1.7	3.4	32.2	45.8	16.9
Dairy industry structure	59	13.6	28.8	57.6	1.7	5.1	32.2	49.2	11.8

Moreover, 'Business relationships' within the supply chain are a source of uncertainty. Other than grass, which is relatively cheap to grow, dairy farmers need fertiliser and supplementary feed to operate the business. Also, 'global supply and demand for food' is

[19] https://www.dairynz.co.nz/news/dairy-exports-up-providing-good-nutrition-for-the-economy/

another source of uncertainty for the farmers, as to their products will be in a supply chain. Among the market uncertainties, more than half of the farmers think that 'business relationships' and 'global supply and demand for food' can provide a possible opportunity for them. When observing the three-dimensional impact of each uncertainty, the survey shows that farmers perceive the impact on their business by 'business relationships' to be 'high' or 'very high' (67%) and by 'global supply and demand for food' (79%). These two items were expected to be perceived as an opportunity since a good 'business relationship' provides a greater opportunity at the local level for the farmers to run their business successfully. Also, a good business relationship at the global level is an opportunity for the dairy industry as well (Junqueira, 2010). Likewise, an expected increase in 'global supply and demand for food' due to the world's population growth provides an opportunity for New Zealand's dairy industry as a large exporter of dairy products[20].

'Milk price', 'reputation & image of the dairy industry', and 'dairy industry structure' present both opportunity and threat for more than half of the respondents. The three-dimensional impact of these three sources of uncertainty shows that the farmers perceive the impact on their business by these uncertainties to be high or very high (59%, 63%, and 61% respectively). Milk price is a significant two-sided source of uncertainty causing threat when it drops and providing opportunity when it sparks. Moreover, the reputation and image of the dairy industry along with the dairy industry structure are also two-sided sources of uncertainty. Since 95% of milk produced in the country is exported[21] and it is required to ensure that dairy exports meet New Zealand food safety standards and the requirements of the overseas customers[22]. Dairy farmers demonstrate that they are aware of the relatively perfect competitive situation of dairy farming in New Zealand.

The ranking of the three-dimensional impacts of market uncertainties as threats having high or very high impact shows that 'input prices and availability of inputs' are of most concern to the farmers. Moreover, ranked second is 'global supply and demand for food' and third is 'global competitors and competition'. Perceiving uncertainties as either an opportunity or a

[20] https://www.statista.com/statistics/732086/new-zealand-milk-production-volume/
[21] https://www.statista.com/statistics/1102885/new-zealand-per-capita-milk-consumption/
[22] https://www.mpi.govt.nz/export/food/dairy/steps-to-exporting/1-meet-new-zealand-requirements-for-dairy-exports/

threat indicates that the farmers have a high awareness of the disturbance caused by each source of uncertainty.

Table 5.5 shows the farmers' perceptions around regulatory uncertainties. Regulations impacting dairy farmers are at three different levels: global, governmental, and local levels.

Table 5.5: Farmers' perceptions of regulatory source of uncertainties

Source of uncertainty	Number of responses	% Of responses			Three-dimensional impact of the uncertainty (% of responses)				
		Opportunity	Threat	Opportunity & threat	Very little	Little	Some	High	Very high
Local body laws and regulations	59	6.8	57.6	35.6	3.4	1.7	6.8	62.7	25.4
Government laws and policies	59	6.8	50.9	42.4	3.4	1.7	8.5	54.2	32.2
The global economic and political situation	59	6.8	35.6	57.6	1.7	3.4	25.4	55.9	13.6

Uncertainty around future changes in regulation at any of the different levels (global, governmental, and local) are not considered as opportunities for the farmers. More than half of them consider changes to 'the local body laws and regulations' and 'government laws and policies' as a threat. Although 'the global economic and political situation' is not considered solely as a threat, it is not seen solely as an opportunity either. Since the reputation of producing and supplying quality dairy products for New Zealand is high[23], the farmers consider the global economic and political situation as two-sided uncertainty. It can provide an opportunity by pushing the competitors out if the food safety standards and the requirements of overseas customers go under more scrutiny. On the other hand, it can be a threat since the New Zealand dairy industry has to focus on its reputation within the global market by meeting the food safety standards and the requirements of overseas customers.

Three-dimensional impacts of the regulatory uncertainties show that the farmers rank the threat posed by 'the local body laws and regulations' as having a high or very high impact on the business (88%). Almost equal is the threat of changes to 'government laws and policies'

[23] https://www.statista.com/statistics/732086/new-zealand-milk-production-volume/

with 86% of high or very high impact on the business. Farmers in New Zealand have faced increasing and changing legislation with which to comply (Valentine, 2015). Therefore, they are familiar with the local and governmental legislation and the threat that these changes can make for their business. Last is 'the global economic and political situation' considered both an opportunity and a threat, has 70% indicating its impact as high or very high. This is, again, related to the New Zealand dairy products export situation and reputation in the world that is not a big threat making uncertainty, but considerable. Dairy farmers know that the global economic and political situation has an impact on their businesses. However, regarding the good reputation of the New Zealand dairy industry, they hope that it will provide an opportunity for them rather than a threat.

The farmers' perceptions of uncertainty from different financial sources are shown in Table 5.6. The sources of uncertainty have been identified as the availability of capital, interest rates, and land value.

Table 5.6: Farmers' perceptions of uncertainty from different financial sources

Source of uncertainty	Number of responses	% Of responses			Three-dimensional impact of the uncertainty (% of responses)				
		Opportunity	Threat	Opportunity & threat	Very little	Little	Some	High	Very high
Availability of capital	59	23.7	44.1	32.2	1.7	5.1	30.5	55.9	6.8
Interest rates	60	16.7	41.7	41.7	0	6.7	23.3	58.3	11.7
Land value	60	23.3	30	46.7	0	6.7	33.3	46.7	13.3

Among the financial uncertainties, 'availability of capital' and 'interest rates' are most likely to be perceived as a threat to the farm business (at 44% and 42% respectively). While 'land value' is perceived as a threat by 30% of the farmers. The three-dimensional impacts of the financial uncertainties show that the threat of 'interest rates' rises is of greatest concern, particularly since interest rates have been very low for some time. The 'availability of capital' is the second biggest concern with 63% suggesting it have a high or very high impact on the business. These results are expected as many farmers have considerable debt financing, so a small increase in interest rates can have serious implications for them. Also, farmers need the availability of capital when they face a disturbance. In this vein, DairyNZ

(2020a) shows that the level of debt to asset ratio for owner-operators was 53.4% and the level of debt to asset ratio for sharemilkers was 61.6% at the end of the season 2018-19 while growth in equity for them was not considerable. This situation illustrates that how much concern can be on the dairy farmers about the interest rate.

The last set of uncertainties is related to their human resources. Table 5.7 shows the farmers' perceptions around uncertainties related to human resources in their farm business.

Table 5.7: Farmers' perceptions of uncertainties related to human resources

Source of uncertainty	Number of responses	% Of responses			Three-dimensional impact of the uncertainty (% of responses)				
		Opportunity	Threat	Opportunity & threat	Very little	Little	Some	High	Very high
Staff and/or personal injury	59	3.4	86.4	10.2	0	6.8	28.8	59.3	5.1
Availability of quality labour	59	5.1	64.4	30.5	1.7	3.4	23.7	55.9	15.3
Staff turnover	59	5.2	48.3	46.6	1.7	3.4	40.7	49.1	5.1
Health and safety compliance	59	18.6	33.9	47.5	3.4	1.7	10.1	76.3	8.5
Job security	58	29.3	24.1	46.3	0	6.9	43.1	43.1	6.9
Skills and knowledge of those associated with the business	59	39.0	11.9	49.1	1.7	5.1	30.5	49.1	13.6

Among the possibility of uncertainties related to human resources, the 'staff and/or personal injury is the most concerning threat for the business (86%). This can be a result of legislation of the Health and Safety at Work Act 2015[24]. The second perceived threat to the farm business is the 'availability of quality labour' (64%). Quality labourers are not available because there has been a change in work expectations for new generation labourers that causes more urbanisation of labour pools (Eastwood et al., 2020). Moreover, expectation changes encourage the new generation to find well-paid positions rather than the longevity

[24] https://www.legislation.govt.nz/act/public/2015/0070/latest/DLM5976660.html

in the traditional path of dairy farming ownership. That is why the staff turnover ranked the third uncertainty for the sample farmers.

Additionally, health and safety compliance, job security, and skills and knowledge of those associated with the business are three human resource uncertainties that are both opportunity and threat. The three-dimensional impact of human resource uncertainties shows that the 'health and safety compliance' ranked first in having a high or very high impact on the business (85%). On one hand, compliance with health and safety guidelines can prevent the business from the consequence of injury or fatalities. On the other hand, not following health and safety guidelines can result in serious injuries or fatalities making the business crippled for a while. An example of fatality was mentioned in Chapter 4 that caused a major change of business location for farmer case 1.

In summary, for Tables 5.3 to Table 5.7, while farmers were not asked to rank them, it would seem that these five sources of uncertainties that present a threat to the farm business are staff and/or personal injury, input prices and availability, availability of quality labour, new local body laws and regulations, and changes to government laws and policies. The top five uncertainties that cause threats to the farmers show that the farmers are well aware of their business environment aligned with disturbances mentioned in Chapter 4. Furthermore, the top five sources of uncertainties that can provide an opportunity for farmers are technological change, business relationships, global supply and demand for food, pasture/crop/animal health, and skills & knowledge of those associated with the business. Then again, these five uncertainties that cause opportunity to the farmers show that the farmers are well aware that they need to be ready to accept changes that open opportunities to their business improvement.

5.3.2 Farmers' perceptions relating to management practices

The statements to elicit farmers' perceptions around recognised practices for managing farms are listed in the left-hand column in Table 5.8. Farmers indicated whether they use each practice on their farms or not. In addition, they indicated the importance of each management practice. This information is presented in Table 5.8.

Table 5.8: Farmers' perceptions relating to different recognised management practices

Management practices	Farmers using this method (%)	Importance of the method (% of responses)				
		Very little	Little	Some	High	Very high
On-farm management practices	-	-	-	-	-	-
Having feed reserves on farm	87.7	0	5.3	14.0	47.4	33.3
Routine spraying and drenching	86.2	0	7.1	32.1	39.3	21.4
Adjusting production methods/systems to comply with laws and policies	84.6	1.8	5.5	34.5	47.3	10.9
Monitoring programmes for pest and diseases control	81.5	1.9	15.1	35.8	32.1	15.1
Implementing technological innovation	80.0	1.9	7.7	42.3	42.3	5.8
Not producing to full capacity	80.0	17.3	11.5	26.9	36.5	7.7
Having infrastructure for soil management (barns, pads, drainage)	76.9	4.0	8.0	32.0	44.0	12.0
Marketing management practices	-	-	-	-	-	-
Gathering market information	78.5	2.0	15.7	37.3	33.3	11.7
Forward contracting	73.8	8.3	4.2	47.9	27.1	12.5
Spreading sales (reducing seasonality in milk production)	64.6	11.9	23.8	40.5	19.0	4.8
Financial management practices	-	-	-	-	-	-
Managing debt levels	87.7	0	1.8	19.3	40.4	38.5
Keeping debt low or increasing equity	87.7	3.5	7.0	24.6	35.1	29.8
Arranging overdraft reserves	80.0	1.9	19.2	28.9	32.7	17.3
Detailed financial planning	81.5	0	5.7	18.9	43.4	32.0
Maintaining financial reserves: having cash and easily converted financial assets	80.0	3.8	9.6	38.5	30.8	17.3
Having off-farm investment	66.2	7.0	20.9	27.9	30.2	14.0
Human-related management practices	-	-	-	-	-	-
Assessing strengths, weakness, threats, and opportunities of farm business	87.7	0	7.0	35.1	40.4	17.5
Having a health & safety plan and keeping health and safety manuals up to date	87.7	7.0	8.8	29.8	29.8	24.6
Having personal and/or business insurance	84.6	1.9	12.7	23.6	38.2	23.6
Unclassified management practices	-	-	-	-	-	-
Enterprise diversification	58.5	5.3	26.3	36.8	18.4	13.2
Using futures markets	52.3	32.4	23.5	35.3	2.9	5.9
Geographic diversity through having properties in different area	40.0	26.9	15.4	42.3	11.5	3.9

The management methods listed in Table 5.8 utilised information from previous studies in New Zealand and are grouped differently for this study. Among the on-farm management practices, 'having feed reserves on-farm' is the most important practice for the farmers employed by 88% of farmers when they consider high or very high importance for this method (81%). Having feed reserve on farm has introduced as one of important solution to optimise feed efficiency in New Zealand dairy farming since it gives farmers more support in longer lactations (Wales & Kolver, 2017). On-farm management practices mostly focus on pasture and animal productivity to optimise milk production and importance for the sample farmers. However, 'not producing to full capacity' in this group of management practices is not about optimising production. It demonstrates that the farmers who rated it as very low, low, and neutral have a higher stocking rate compare to those who rated it high and very high (Shadbolt & Olubode-Awosola, 2013). In addition, 'not producing to full capacity' was introduced as managing risks in short-terms mostly used by low resilient farmers (Duranovich, 2015). Therefore, 56% of the sample farmers have a higher stocking rate compared to the other 44%, potentially associated with high resilient farmers.

When considering marketing management practices, 'gathering market information' is mostly employed by 79% of the farmers and 'forward contracting' by 74%. In addition, 'spreading sales' is less applicable for farmers. This is because of pasture based dairy farming in New Zealand that is dependent on the pasture growing season. Therefore, most of dairy farms' peak sale is in sprig season. The importance of these three marketing management practices is not high or very high. Moreover, marketing strategies are not highly important to the farmers because of the intervention of the cooperative Fonterra, which has an important role in managing market risks for New Zealand dairy farmers (Duranovich, 2015).

Among financial management practices, 'managing debt level' and 'keeping debt level low or increasing equity' are mostly used by the farmers. However, managing debt level is high and very high importance for the farmers (79%) compared to keeping debt level low or increasing equity (65%). In this vein, Shadbolt and Olubode-Awosola (2013) mentioned a commonly shared view in New Zealand that high level of debt drive good management. Furthermore, information from DairyNZ (2020a) demonstrate that increase in debt level has been higher than increase in equity after season 2013-14. The financial management

practice ‘having off-farm investment’ is less applicable for farmers and it is 44% of high or very high importance. This is because of intensive dairy farming structure in New Zealand, where farmers tend to have more family and non-family staff employed in their farm that makes working or investing off-farm not applicable for managing risk in the dairy farm business (Duranovich, 2015).

The other management practices are human-related, in which, ‘having personal and/or business insurance’ is less employed compared to the other two management practices in this group. Its importance (62%) is higher than the other two and it focuses on coping with risks in long-term. The farmers tend to apply ‘having a health & safety plan and keeping health and safety manuals up to date’ because of new legislations on workplace safety act in 2015. However, looking into the importance of this practice shows that it is less important than the other human-related management practices.

Some of these management practices do not apply to all the farmers. For instance, ‘geographic diversity’, ‘using futures market’, and ‘enterprise diversification’ are less applicable and less important practices for the sample farmers. The last group in Table 5.8 are named unclassified management practices. In this group, ‘enterprise diversification’ is 32% of high or very high importance and ‘using future markets’ is 9% of high or very high importance. These are aligned with previous studies demonstrating enterprise diversification or geographic diversity through having properties in different area as the least adopted management practices. In addition, ‘using future markets’ is less adopted because of intervention of the cooperative Fonterra (Duranovich, 2015).

In summary, in Table 5.8, while farmers were not asked to rank the management practices, it would seem that the top five applicable management practices for the farm business, meanwhile 88% of the farmers using these methods, are: 1) having feed reserves on farm, 2) managing debt levels, 3) keeping debt low or increasing equity, 4) assessing strengths, weakness, threats, and opportunities of farm business, and 5) having a health & safety plan and keeping health and safety manuals up to date. The importance (high or very high importance) of these top five management practices for the sample farmers are 81%, 79%, 62%, 58%, and 54% respectively.

5.3.3 Farmers' perceptions of the five capitals

The farmers indicated their perceptions of five capitals in different sections of the survey. The statements about each capital are grouped and the numerous tables of the raw data results for each capital are presented in Appendix 5 and will be referred to in the subsections which follow.

5.3.3.1 Natural capital

Regarding the dairy farming context in New Zealand, six statements were designed to capture dairy farmers' perceptions of their natural capital. The distribution of responses for the statements presented in the survey are shown in Table 5.9.

Table 5.9: Distribution of respondents' perceptions of natural capital

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I aim to minimise the use of agricultural chemicals on the farm to protect the environment.	65	0	3.1	32.3	56.9	7.7
I have tried to consider our business environmental footprint of our business and improve it to prevent future environmental costs.	65	0	0	6.2	55.3	38.5
I know sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.	65	6.2	13.9	21.5	49.2	9.2
I am willing to accept land-conserving costs beside my operation costs	65	1.5	6.2	23.1	55.3	13.9
Improving environmental footprint has imposed some costs on our business	65	0	1.5	7.7	50.8	40.0
I aim to diversify my assets by having on-farm and off-farm investments	65	0	15.4	24.6	44.6	15.4

It shows that almost two-thirds of the farmers expressed their desire to protect the environment by minimising the use of agricultural chemicals. In addition, almost all, (94%) of the farmers see themselves as farmers who have tried to consider the environmental footprint of their business and to improve it to prevent future environmental costs. However, 58% of farmers agree or strongly agree that sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.

In addition, 69% of them are willing to accept land-conserving costs besides their operation costs. In this vein, 96% agree or strongly agree that improving their environmental footprint has already imposed some costs on their business. Furthermore, having on-farm and off-farm investments is a way of diversifying their assets. The diversification in assets can decrease production risks and keep profitability at an acceptable level. Diversifying the assets is of interest to 60% of the farmers, while 40% of them are neutral or disagree about this statement. Looking back into the management practices for the sample farmers shows that having off-farm investment and diversifying the assets is not considerably practical for most of the farmers.

5.3.3.2 Physical capital

Physical capital relates to the livestock, pasture, and infrastructure of the farm business. The focus here is on farmers' perceptions of the importance of their physical capital and whether they are interested in working to improve that physical capital. Their responses to the statements presented in the survey are shown in Table 5.10.

Table 5.10: Distribution of respondents' perceptions of physical capital

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
It is important to have the best quality livestock.	64	0	0	6.2	32.3	61.5
It is important to have the best quality pasture.	65	0	0	6.2	32.3	61.5
I try to build the infrastructure on my farm over time (gradually).	64	0	6.3	14.1	59.3	20.3
For my farm business, fertiliser management is necessary.	64	1.6	1.6	7.8	50.0	39.0
I reckon animal welfare is positively correlated with profitability.	64	0	1.6	12.5	57.8	28.1

Nearly all the farmers (94%) agree or strongly agree that having the best quality livestock and the best quality of pasture, are important for their business. In addition, fertiliser management is perceived to be extremely important (89%). Animal welfare (86%) is deemed important and positively correlated with the profitability of their farm business. Finally, gradual improvement in infrastructure is of importance (80%) to these farmers. Based on dairy farm infrastructure definitions by DairyNZ (2012), infrastructure includes

drainage, management & maintenance of feed pads, road underpasses, and effluent management. Since regional councils have been enforcing tighter environmental regulations, considering the importance of the factors related to sustainable management of the farm, improvement in infrastructure and animal welfare helps to increase adaptive capacity facing upcoming regulations. Improvement in on-farm structures such as feed pads or animal shelters/housing achieve better feed conversion efficiencies and on-farm effluent management is an influential factor to cope with the containments, and the application of a wide range of effluents (Longhurst et al., 2017).

5.3.3.3 Financial capital

The section designed for financial capital in the survey includes the importance of profit-making and financial prosperity. Considering farmers in the way whether they are financially driven or not is a dimension of their adaptive capacity when tighter environmental regulations expect more environmentally driven farmers. Their responses to the statements presented in the survey are in Table 5.11.

Table 5.11: Distribution of respondents' perceptions of financial capital

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I aim to make the largest possible profit.	65	0	7.7	33.8	43.1	15.4
Financial prosperity is a key goal and the primary reason for expanding the business.	65	0	7.7	21.5	47.7	23.1
I want to operate this farm for the rest of my life and pass it on to my children.	65	9.2	18.5	35.4	21.5	15.4
I want to sell the farm for a reasonable price when I get close to retirement.	64	17.2	15.6	28.1	21.9	17.2

For the surveyed farmers, 71% agreed or strongly agreed that financial prosperity is a key goal and the primary reason for expanding the business, while 59% agree or strongly agree that their aim is to make the largest possible profit. These responses show that the financial intensives are important, however, from another perspective, it can be said that 41% of dairy farmers pay attention to the environment by gaining less profit. In other words, it can be said that dairy farmers are getting ready to be adaptive by accepting less profit instead of the largest profit.

To elicit long-term or future financial intentions, farmers were asked to indicate whether they intended to keep the business to pass on to their children or whether they intended to sell it when they are ready to retire. This sample of farmers was reasonably evenly split around these two alternatives. Around 37% agreed or strongly agreed that the farm business would be passed on to their children, while 35% indicated they were neutral, which likely means that succession is undecided at this point in time. Since the two statements are linked, this group of farmers is similarly undecided as to whether they will sell the farm business as they retire with 39% agreed or strongly agreed they will sell the business. In New Zealand, historically, families grew up on farms, and either the oldest boy carried on the farm or one of the boys decided to take the business. Nowadays, it is different. The value of the farm is much higher and to split the inheritance among the children the farm business needs to be sold.

5.3.3.4 Human capital

Human capital was explored through the attributes of the dairy farm's main decision-maker. The first attribute of human capital, 'background' covered different effects of the family situation on the farmer from the past to the present. This included job choice and passion for the work. The first attribute was asked through six statements presented in Table 5.12. The family background in dairying had an influence on 47% of the farmers. However, the majority of farmers (58%) stated that they chose their career without any influence from the family. The effect of family situation on the farming operation is high (72%) but the family labour influence on the farming operation is not high, 30% agreed or strongly agreed, while 25% were neutral. When asked directly, they assessed their passion for dairy farming as very high (91%), however, more than two-thirds of farmers (69%) intended work hard to improve their work-life balance in the future.

Table 5.12: Distribution of respondents' perceptions of human capital (background, job choice/passion)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
My family background in dairying has had an influence on my choice of a dairy farm business career.	65	20.0	26.2	9.2	23.1	21.5
Dairy farming has been my career choice without any influence from the family.	65	0	23.1	18.5	35.3	23.1
The family situation influences my decisions about farming operation.	65	0	10.8	16.9	46.2	26.1
Family labour is an important part of my farm business.	64	21.9	23.4	25.0	10.9	18.8
I am passionate about agriculture and dairy farming.	65	0	0	9.2	38.5	52.3
At the moment, I am happy to do the hard work to get more work-life balance in the future.	65	0	7.7	23.1	52.3	16.9

The second attribute of human capital is the locus of control, indicating the farmer's general expectations and perceptions around having control over the success of the farm business. The majority of farmers indicated signs of internal locus of control, in which they believed that they had control over external pressures (Table 5.13).

Table 5.13: Distribution of respondents' perceptions of human capital (locus of control)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The success of my farm business is mostly determined by factors outside of my control.	65	10.7	43.1	20.0	18.5	7.7
Any loss in milk production from future environmental requirements will prevent my business from achieving long-term goals.	64	6.3	28.1	34.4	21.8	9.4
N leaching targets have had an impact on our business.	64	9.4	26.6	32.8	18.7	12.5

In this respect, 54% of farmers stated that the success of their business is within their control, rather than being determined by factors outside their control. It is relatively easy to say that the success of their business is in their control, however, when presented with external pressures in the survey, their responses help reveal whether they still feel in

control. When it came to any loss of milk production as a result of likely future environmental regulations preventing the achievement of long-term business goals, the farmers were less sure and were equally split between agreement, neutrality, and disagreement. The same was the case when presented with nitrate leaching targets impacting the business. These two statements dig deeper into the locus of control, and these suggest that less than half of these farmers believe they have control over the success of their business when faced with specific external pressures.

The third attribute of human capital is self-efficacy, where the farmers show their belief in their own capacity to overcome stressful situations. Beliefs of self-efficacy are important to predict risk management understanding with a strong positive belief about their ability to manage risks. Perceptions around this belief were revealed when responding to four statements presented in Table 5.14.

Table 5.14: Distribution of respondents' perceptions of human capital (self-efficacy)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree/Very little	Disagree/ Little	Neutral/ Some	Agree/ High	Strongly agree/Very high
How much influence on "Long-term" decision making	64	1.6	0	14.0	26.6	57.8
How much influence on "Within the season" decision making	65	1.5	3.1	16.9	40.0	38.5
How much influence on "Day-to-day" decision making	64	14.1	15.6	18.7	14.1	37.5
I am confident that I can make "big" decisions correctly.	65	0	1.5	4.6	53.9	40.0

Three statements focus on the influence that farmers have on decision-making over the different periods: long-term, within a season, and day-to-day. These differing perceptions for different temporal dimensions suggest the risky nature of agricultural activities that affects a farmer's self-efficacy, where their influence on long-term decision-making is higher than within-season decision-making and day-to-day decision-making. The other statement is around the farmer's perceptions of their own confidence to make "big" decisions correctly. In this respect, nearly all the farmers (94%) agreed or strongly agreed that they are confident in their ability to make these "big" decisions correctly.

The fourth attribute of human capital is sense-making, a skill that is related to the concept of bounded rationality (Boland, 2008). Sense-making provides the ability to; understand connections to predict and act effectively (Klein et al., 2006a); to make sense of uncertain situations (Gioia & Chittipeddi, 1991); to recognise opportunities or threats for the business when facing new situations (McCann et al., 2009). The distribution of responses for the statements in the survey is presented in Table 5.15.

Table 5.15: Distribution of respondents' perceptions of human capital (sense-making)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am not good at making sense of ambiguous and uncertain situations.	64	12.5	56.3	18.8	10.8	1.6
When there are a number of solutions to a problem, I find it difficult to make a choice.	65	7.7	52.3	20.0	16.9	3.1
When confronted with a new situation, I review past experiences to assess the situation.	65	0	3.1	13.8	66.2	16.9
Over the long term, I am able to manage almost all uncertainties that occurs.	65	3.1	20.0	27.7	44.6	4.6
I do not think of regulations as having a negative influence on my dairy business.	65	12.3	32.3	20.0	30.8	4.6
I take every opportunity to expand my business.	65	4.6	13.8	47.7	32.3	1.5

Two third of the farmers (69%) stated that they are good at making sense of ambiguous and uncertain situations and 60% do not find it difficult to choose between several solutions to a problem. In addition, 81% of the farmers indicated that they review their past experiences to assess new situations. In the long term, only 49% of the farmers agree that they can manage uncertainties, which is not aligned with their perceptions of having a high influence on long-term decision-making presented in self-efficacy section. This can be a hint of difference between the farmer's expectation of themselves and the reality when it comes to uncertainties. With regard to regulations, only 35% of the farmers think that the regulations have a negative influence on the dairy business, 20% are neutral about regulations and 45% disagree or strongly disagree with regulations having a negative impact on the business. Looking back at the financial intensives (mentioned in the financial capital section), most farmers focus on profitability rather than regulations which impact their adaptive capacity in long term facing upcoming regulations. It can be said that they focus on profitability which is

useful to decrease debt to asset ratio. However, DairyNZ (2020a) demonstrates that most farmers do not try to decrease the debt to asset ratio. In addition, perceptions around taking opportunities to expand the business are varied with one-third agreeing or strongly agreeing with this statement and nearly half (48%) of the farmers being neutral about taking every opportunity to expand the business. As a consequence, profitability and financial prosperity will increase their buffer capacity when facing a sudden change, however, it does not increase the adaptive capacity when environmental regulations are more stringent.

The fifth attribute of human capital is strategic thinking, which emphasises holistic thinking and an ability to implement the most appropriate decision to achieve business goals. Perceptions around this attribute were expressed by responses to four statements shown in Table 5.16.

Table 5.16: Distribution of respondents' perceptions of human capital (strategic thinking)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
When it comes to business, I like to play it safe.	65	3.1	10.8	36.9	40.0	9.2
I review my farm business goals and plans on a regular basis (e.g. annually).	65	0	9.2	21.5	46.2	23.1
I prefer to be ahead of the regulations and then I know I am doing the best I can do.	63	0	1.6	4.8	61.9	31.7
I have been thinking of farm business scale, then considering expanding the business.	64	4.7	18.8	46.9	23.4	6.2

The first statement concerns strategic risk-taking in the business. Almost one-half agree or strongly agree that they play it safe and only 14% disagree or strongly disagree, suggesting that more of the farmers are risk-averse when it comes to strategic thinking and vision for their farm business. According to the literature, most farmers have good skills and experience, however, they would not take risks or experiment with activities that are outside their field of competence (Duranovich, 2015; Olsson, 1988; Shadbolt & Olubode-Awosola, 2013). In the second statement, two-thirds of the farmers review the farm business goals and plans regularly. The review of goals and plans helps them to see how different parts of the farm system impact each other in the short and long terms

(Duranovich, 2015). The farmers' perceptions around likely future regulations show that nearly all of them prefer to be ahead of likely regulations. Consequently, this suggests that they will try to learn more about upcoming regulations. The last statement, focusing on the scale of the business and consideration of business expansion reveals a varied response by the sample farmers. Approximately 30% agree or strongly agree and 24% disagree or strongly disagree, which may support the perception of not taking opportunities to expand the business. Thus, strategic thinking in terms of keeping the current size of the business may suggest working more effectively to be able to implement the most appropriate decision to achieve business goals such as financial prosperity.

The sixth attribute of human capital is the willingness to accept change. The first step to accepting change is being willing to accept change and then making time to implement the changes. Responses to the six statements shown in Table 5.17 proffered to investigate perceptions around their 'willingness to accept change' suggest these farmers perceive themselves as very willing to accept change.

Table 5.17: Distribution of respondents' perceptions of human capital (willingness to accept change)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am aware that there will always be regulation yet to come in.	64	0	0	3.1	68.8	28.1
I think gaining consents will be tougher when in the future we wish to renew current consents.	64	0	0	3.1	57.8	39.1
I know the stocking rate is going to come under more scrutiny.	64	0	1.6	7.8	62.5	28.1
I intend to make time to implement changes required in my farm business.	65	0	0	9.2	75.4	15.4
I have thought about changing my land use if environmental issues prevent us from continuing to run a dairy operation.	64	7.8	37.5	18.7	34.4	1.6
I have thought about exiting the dairy industry if environmental issues prevent us from continuing.	64	12.5	56.3	18.7	10.9	1.6

Nearly all agree or strongly agree with the statements given. In this respect, 97% stated that they know there will always be regulations yet to come. Because of such upcoming

regulations, 97% of the farmers know that gaining consent will be tougher in the future when they wish to renew current consents. The same is the case regarding the likelihood of the stocking rate under more scrutiny, with 91% of the farmers being aware that this will likely happen. In addition, 91% of farmers intended to make time to implement the changes required in their farm business. However, 45% have not thought about radical changes such as changing their land use if environmental issues prevent them from continuing to run a profitable dairy operation. Also, one in five are neutral about changing land use. The final statement about exiting the dairy industry if environmental issues prevent them from continuing, reveals that only 13% agree or strongly agree with this statement. These perceptions around changing land use or exiting the dairy industry suggest that although the farmers explain their willingness to accept changes, most of them have not yet considered a practical plan when faced with these particular changes or pressures. This difference highlights that farmers' actions can be different from their perceptions.

The seventh attribute of human capital is open-mindedness, which means being open to accepting changes and adapting to them. Most farmers (more than 85%) show signs of open-mindedness as they agreed or strongly agreed with the statements presented in Table 5.18. They barely disagree or are neutral when responding to the statements.

Table 5.18: Distribution of respondents' perceptions of human capital (open-mindedness)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I consider everyone in the dairy industry learns from each other.	65	0	0	10.8	38.5	50.7
I value the knowledge of others from inside and outside the farm business.	65	0	0	3.1	52.3	44.6
I am interested in university research looking to find good solutions regarding my farm business conditions.	65	0	0	13.8	47.7	38.5
I try to keep myself informed.	65	0	0	1.5	50.8	47.7
I think I am still learning about dairying.	65	0	0	9.2	63.1	27.7
I have regular contact with other members of the industry to acquire knowledge.	65	0	1.5	3.1	61.5	33.9
I am open to DairyNZ and am happy to be in discussion groups and the like.	65	0	1.5	13.8	47.8	36.9

In this respect, 89% of the sample farmers consider everyone in the dairy industry learns from each other and 97% of the farmers value the knowledge of others from both inside and outside the farm business. The other five statements reflect the farmers' perceptions about learning and acquiring knowledge about dairying via university research, industry members, and discussion groups. For these five statements, more than 85% of the farmers were in agreement. Being open to learn from every possible source of information and knowledge reflects open-mindedness on the part of these farmers. This is consistent with previous research on New Zealand dairy farmers' resilience by Duranovich (2015). In addition, some statements related to open-mindedness were considered as aspects of social capital as will be seen in the next session.

5.3.3.5 Social capital

Aspects of social capital have been investigated via responses to six groups of statements. Three of these focus on connections with other people; the value of other people's input in the farmer's decision-making, connections with others as a source of information, and involvement with others for their own sake as well as for the business. Further to this, there are three types of relationships investigated in terms of their importance: bonding, bridging, and linking.

Regarding the value of other people as social capital, nearly all survey farmers value the views of people they consider trustworthy, when they make decisions (Table 5.19).

Table 5.19: Distribution of respondents' perceptions of social capital (value of social capital)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
When I make a decision, I turn to trustworthy people in relation to my farm to get their points of views.	65	0	0	7.7	64.6	27.7
I value the knowledge of others from inside and outside the farm business.	65	0	0	3.1	52.3	44.6
I believe being in touch with vets regularly will help animal health.	65	0	3.1	20.0	53.8	23.1

In this respect, 92% of farmers agreed or strongly agreed with turning to trustworthy people in relation to their farm business decisions. Trustworthy people for farmers can be in their

bonding, bridging, or linking social capital and every farmer has their own priorities when choosing trustworthy people. Also, the farmer's perceptions about how they value the knowledge of others from both inside and outside the farm business (97%), emphasises the value of social capital for the farmers. For example, when asked about being in touch with veterinarians regularly, more than three-quarters of farmers (77%) believed that recommendations from the vet will help animal health in their business.

Nearly all the surveyed farmers said their external connections were not only a source of information, but a valuable connection to the world outside of the business (Table 5.20).

Table 5.20: Distribution of respondents' perceptions of social capital (source of information)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I have regular contact with other members of the industry to acquire knowledge.	65	0	1.5	3.1	61.5	33.9
I have regular contact with other farmers where we discuss environmental restrictions.	65	0	6.2	32.3	40.0	21.5
I try networking and talking to other farmers to get more information and practical management.	65	0	6.2	15.4	58.4	20.0
I am keen on reading newspapers or magazines with Dairy news.	64	1.6	3.1	9.4	48.4	37.5
I use the Internet regularly to keep myself informed.	65	0	4.6	12.3	56.9	26.2

In this respect, 95% have regular contact with other members of the industry to acquire knowledge. The majority of them (62%) have regular contact with other farmers where they discuss environmental restrictions. Getting more information and practical management suggestions by networking and talking to other farmers is the case for 78% of these farmers. In addition, reading newspapers or magazines with dairy-related news is of interest to 86% of the farmers, and 83% used the internet regularly to keep informed. This high percentage of responses regarding the farmers' connections outside of their business revealed social capital as an important source of information, which is aligned with the literature (Jansen et al., 2013).

Involvement with other people in discussion groups or community activities was established. In addition, the importance of business reputation was asked (Table 5.21).

Table 5.21: Distribution of respondents' perceptions of social capital (the involvement)

Statement	Number of responses	Percentage of responses (%)				
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am open to DairyNZ and am happy to be in discussion groups and the like.	65	0	1.5	13.9	47.7	36.9
I am quite involved in community activities.	65	1.5	12.3	30.8	27.7	27.7
My business reputation is very important and provides me with reasonable opportunities.	64	0	0	4.7	53.1	42.2

The farmers' involvement in discussion groups (85%) and community activities (55%) suggested the importance of social involvement to the farmers. Also, business reputation is highly important for the farmers to provide reasonable opportunities for the majority of farmers (95%). The involvement in a range of discussion or community activities shows an inter-related social networking and social participation (Foxton & Jones, 2011). In addition, business reputation provides owner-operators a good image to the bankers when they need financial help. Moreover, it is important for 50-50 sharemilkers to get broader opportunities for sharemilking.

People within three types of social capital are important for the farmers. The importance of three types of relationships with others was identified in the survey (Table 5.22). For 'bonding' social capital, which is a connection with people from the same rank, partner and family are the most important people with 63% rating them as very important. Also, 37% of the farmers mentioned "partner and family" as important or highly important to confer with, when considering important decisions or whether to implement changes in their farm business. In fact, all farmers mentioned "partner and family" as important when making 'big' decisions. Although friends and other farmers are in the same social ranking, none of them are considered very highly important to the farmer when making 'big' decisions. However, other farmers are rated important by 50% and friends are rated important by 51%. Also, staff who are working in the farm business are rated as important (by 82%) for decision-making.

Table 5.22: Distribution of respondents' perceptions of social capital (bonding, bridging, linking)

Statement	Number of responses	Percentage of responses (%)				
		Very little important	Little important	Important	Highly important	Very high importance
Bonding	-	-	-	-	-	-
Partner and family	65	0	0	7.7	29.2	63.1
Friends	63	9.5	39.7	39.7	11.1	0
Other farmers (e.g. neighbours)	64	15.6	34.4	37.5	12.5	0
Staff	65	3.1	15.4	46.1	29.2	6.2
Bridging	-	-	-	-	-	-
Accountant	65	1.5	12.3	33.9	40.0	12.3
Longstanding farm advisor	65	20.0	4.6	18.5	40.0	16.9
Another consultant when I need specialist advice	63	19.1	6.3	39.7	22.2	12.7
Veterinaries	65	9.2	20.0	27.7	30.8	12.3
Fertiliser and seed representatives or AI technicians	64	26.6	20.3	32.8	17.2	3.1
Academic people	65	21.6	29.2	36.9	9.2	3.1
DairyNZ staff	65	21.6	32.3	32.3	12.3	1.5
Feed suppliers	65	26.2	35.4	35.4	3.1	0
Linking	-	-	-	-	-	-
Banker	65	0	6.2	26.1	43.1	24.6
Milk company staff (e.g. Fonterra, Open country, etc.)	65	13.9	20.0	43.1	21.5	1.5
Regional council staff	65	23.1	10.8	46.1	15.4	4.6
Board of Directors	62	41.9	21.0	11.3	17.7	8.1

Termed 'bridging' social capital, accountants, longstanding farm advisors, and consultants (for specialist advice when needed) are considered the most important people, by 86%, 75%, and 75% respectively, by the farmers. Veterinarians are considered important by 71% of the farmers. The other important people for 'bridging' are fertilizer & seed representatives or Artificial insemination (AI) technicians (by 53% of the farmers). However, academics, DairyNZ staff, and Feed suppliers are of little or very little importance at 49%, 46%, and 38% (respectively) to be involved in 'important' decisions for the farmers. 'Bridging' social capital provides connections with experts who differ from the farmers, but their involvement in making 'important' decisions is high. Highlighted here is the greater

importance to the farmer of those directly involved with the decisions, like accountants, longstanding farm advisors, consultants, and veterinarians. While deemed less important, academics, DairyNZ staff, and feed suppliers still make some contribution to help the thinking and decisions around implementing changes in the farm business.

'Linking' social capital demonstrates the importance of those people representing organisations or institutes with power over the business. Among the four groups of people listed in the survey, bankers are recognised as of the highest importance to the farmers (94% are either important, highly important, or of very high importance). Therefore, the role of bankers is very high when the farmers are going to make decisions and implement changes in their farm business. Milk company staff and Regional Council staff are ranked second with 66% importance. The importance of boards of directors is 37%, possibly because 50-50 sharemilkers make up 21% of the sample farmers. In this survey, 62% of farmers are farm owners (including operators and/or non-operators) and 17% are equity partners. Where the owner operators and equity partners ranked very little or little for boards of directors in the survey.

5.4 Results for two weighting methods

Perceived adaptive capacity is captured through the farmers' perceptions about possible uncertainties, known management practices, and the five capitals. The following sections describe the results of the two weighting methods, PCA and EW.

5.4.1 Principal Component Analysis weighting

The survey statements are the "variables" for the principal component analysis (PCA). For each of the seven dimensions, the PCA is used to transform the variables into the first component, which is a linear combination of that dimension's variables. For a PCA, the sample size in this study was an important matter, and in addition, complete data were required. The sample size was relatively small, and the first components (of the dimensions) were defined by several statements with high communalities. In order to have a reasonable sample size, the missing values were treated in a pairwise manner (as outlined in Chapter 3, section 3.4.3.1.b). In addition, splitting the data into blocks for dimensions and blocks within human and social capital dimensions addressed the issue of the relatively small sample size and helped increase the loadings for each variable. A value of 0.4 or greater for the loadings

indicates the statements that are strongly related to the principal component of each block.[25] For instance, there are six statements for natural capital. Therefore, for the natural capital-related group, the number of statements is 6 ($p = 6$) and the number of respondents is 65 ($N = 65$). This gives an $N{:}\,p$ ratio of 11:1, which is a reasonable practical ratio for PCA[26]. The sufficiency of the sample for each block of data is supported by the results of the KMO test and Bartlett's Test of Sphericity[27]. Moreover, the eigenvalues associated with the first component for each block of data represent the percentage of variance explained in the correlation matrix by the first component. Table 5.23 shows the $N{:}\,p$ ratio, KMO test, Bartlett's test of Sphericity, and the variance associated with the first component for each block of data.

Table 5.23: Sample sufficiency for the PCA and the percentage of variance

Dimensions	N:P ratio	KMO	Bartlett's test	% Of Variance for the first component
Uncertainties	$65{:}\,16 \cong 4{:}\,1$	**0.9**	**0.00**	**51.23**
Management practices	$65{:}\,22 \cong 3{:}\,1$	**0.6**	**0.00**	**29.72**
Natural capital	$65{:}\,6 \cong 11{:}\,1$	**0.6**	**0.00**	**30.78**
Physical capital	$65{:}\,5 \cong 13{:}\,1$	**0.5**	**0.00**	**42.58**
Financial capital	$65{:}\,4 \cong 16{:}\,1$	**0.5**	**0.00**	**40.17**
Human capital	$65{:}\,7 \cong 9{:}\,1$	**0.5**	**0.00**	**23.06**
background	$65{:}\,5 \cong 13{:}\,1$	0.5	0.03	31.68
Locus of Control	$65{:}\,3 \cong 22{:}\,1$	0.4	0.01	45.26
Self-efficacy	$65{:}\,4 \cong 16{:}\,1$	0.5	0.00	46.91
Sense-making	$65{:}\,5 \cong 13{:}\,1$	0.6	0.00	37.19
Strategic thinking	$65{:}\,4 \cong 16{:}\,1$	0.5	0.03	36.56
Willingness to accept change	$65{:}\,6 \cong 11{:}\,1$	0.5	0.00	29.65
Open-mindedness	$65{:}\,7 \cong 9{:}\,1$	0.7	0.00	37.72
Social capital	$65{:}\,6 \cong 11{:}\,1$	**0.7**	**0.00**	**42.83**
Value of trustworthy people	$65{:}\,3 \cong 22{:}\,1$	0.5	0.00	51.95
Source of information	$65{:}\,5 \cong 13{:}\,1$	0.6	0.00	36.58
Involvement in community	$65{:}\,3 \cong 22{:}\,1$	0.5	0.01	48.58
Bonding	$65{:}\,4 \cong 16{:}\,1$	0.6	0.01	39.92
Bridging	$65{:}\,8 \cong 8{:}\,1$	0.8	0.00	44.39
Linking	$65{:}\,4 \cong 16{:}\,1$	0.6	0.00	43.76

The criterion of an eigenvalue ≥ 1 is a useful and often used approach to define the number of components selected as a crude method based on eigenvalue thresholding (Minka,

[25] Examples of principal component analysis output are shown in appendix 4.
[26] Acceptable N:p ratio varies from 3:1 to 15:1 (Field, 2013; Hair et al., 1998)
[27] KMO > 0.5 and Bartlett: p < 0.05 indicate the sufficiency of the sample (Field, 2013; Hair et al., 1998)

2001)[28]. Eigenvalues ≥ 1 account for the percentage of the variation in the data shows the number of components that can be selected. However, as the first principal component (PC) was needed to determine the weighting of the variables in the construction of the PC score, the percentage of variance explained in the correlation matrix is a way of measuring the inter-sample heterogeneity (Zhao & Xue, 2017).

The diversity of the sample farmers' perceptions is revealed by the variance in their perceptions of these seven dimensions. Perceptions of uncertainty around the disturbances they have or may face showing the greatest variation (51.23%). This might be expected, since how the farmers perceive the disturbances will vary based on their differing business environments, in terms of location and natural environment, the financial structure of the business, and their human capital, for instance. These will influence their risk appraisal of the particular disturbance. In contrast, human capital has the lowest variance (23.06%) compared with the other dimensions. It might be said that uncertainty is the first sight of disturbance, however, when it comes to express the ability to cope with disturbances (through human capital and management practices) there is less variation in the responses. This may suggest that most dairy farmers in New Zealand use similar routine management practices. This will be discussed further in Chapter 6.

The next step was a bottom-up process of calculating PCA scores for the seven attributes within human capital, the six aspects of social capital[29], and then the seven identified dimensions for perceived adaptive capacity. Firstly, the PCA produced the weighting for the different statements (variables) for each farmer. Secondly, the scores were calculated by the sum of the component score coefficients multiplied by the original Likert scale responses (as outlined in Chapter 3, Section 3.4.3.1.c).

The PCA scores ranged from 1 (less important) to 9 (highly important) on the ranking scale (see Chapter 3, Section 3.4.3.3). Finally, the score for the seven dimensions for every respondent was used for further analysis in the Analytical Hierarchy Process (AHP), the results of which are presented in Section 5.5.1.

[28] Eigenvalues are not reported here, since the first component was chosen as a weighted combination of variables. Instead, the percentage of variation for the first component is reported.
[29] An example of output to the bottom-up process in Appendix 4.

5.4.2 Equal weighting

The other method of weighting used here was where the statements are given equal weighting for calculating the scores of the seven dimensions. The equal weighting for the different variables (statements) for each farmer, is the sum of the original Likert scale divided by the number of variables for each farmer. For example, Farmer X (one of the sample farmers) responded to the natural capital-related statements as below (Table 5.24). The equal weighting score of natural capital perceptions for farmer X is: $\frac{3+4+2+1+5+3}{6} = 3$.

Table 5.24: An example of equal weighting for natural capital perceptions of Farmer X

	Statement	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
1	I aim to minimise the use of agricultural chemicals on the farm to protect the environment.			✓		
2	I have tried to consider our business environmental footprint of our business and improve it to prevent future environmental costs.				✓	
3	I know sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.		✓			
4	I am willing to accept land-conserving costs besides my operation costs	✓				
5	Improving environmental footprint has imposed some costs on our business					✓
6	I aim to diversify my assets by having on-farm and off-farm investments			✓		

The equal weighting scores varied from 1 ('less important') to 5 ('highly important') in the ranking scale (see Chapter 3, Section 3.4.3.2). Then, the score of the dimensions for every farmer was used for further analysis in the Analytical Hierarchy Process (AHP), and results are presented in Section 5.5.2.

5.5 Analytical Hierarchy Process

After the process of calculating the PCA weighting score and the EW score for each of the seven dimensions for each farmer, the next stage is the Analytical Hierarchy Process (AHP), which was used in the development of a perceived adaptive capacity index for each farmer. AHP uses the word "criteria" instead of dimensions (see Chapter 3, Section 3.4.3.3). The criteria were defined according to the literature using uncertainty, management, and the five-capitals framework (Grothmann & Patt, 2005; Lemos et al., 2016; Lockwood et al., 2015). The statements from the questionnaire were matched to these criteria.

The final calculated scores (both the PCA weighting score and the EW score), for every farmer who had completed the survey with no missing data[30], were used in the AHP, this left 55 farmers. Through the AHP, the relative importance of uncertainty, management, and each of the five capitals is revealed in the decision-making process of each farmer. Every farmer reveals their own relative importance for the seven criteria. The relative importance (as weights) is utilised in calculating each farmer's perceived adaptive capacity index. The process of assigning relative importance (weight) to each criterion required a relative scale of priorities (see Chapter 3, Section 3.4.3.3). Through the AHP, it was also possible to assign relative importance for the human and social capital sub-criteria. Calculating the relative importance of the sub-criteria (presented in Appendix 5 and Appendix 6) was possible for all 65 farmers since missing data were mostly in uncertainty and management practices dimensions. The relative importance of sub-criteria for human and social capital was useful to investigate each farmer's perceptions of these two capitals is discussed in more detail in the discussion chapter, Chapter 6.

5.5.1 AHP for PCA weighting scores

The calculated PCA scores varied from 1 (less important) to 9 (highly important). The pair-wise comparison matrix for each farmer was made based on the ranking scale provided in Chapter 3 (Section 3.4.3.3, Tables 3.6 and 3.6). Explained here is the AHP analysis results for one of the sample farmers as an example, who is called Farmer X. This farmer has PCA scores for the seven criteria, uncertainty (U=6), management (M=9), natural (N=7), physical (P=6), financial (F=5), human (H=5), and social (S=8). The comparison was described in Chapter 3 (Table 3.6). Here is the example to illustrate the values in the pair-wise comparison matrix for Farmer X. The comparison of each criterion to itself, with a value of 1 indicates equal importance. Moreover, comparing criterion with the same score such as F(5) and H (5) , also, shows the value of 1. The value for a_{21} is the value of comparing M (9) with U (6), which is 4, while a_{12} is obtained by comparing U (6) with M (9), which is the reciprocal of a_{12} (i.e., $a_{21} = \frac{1}{4} = 0.25$). Similarly, the value for a_{13} is obtained by comparing N (7) with U (6), which is 2. While a_{31} is the value of comparing U (6) with N (7), which is the reciprocal

[30] Missing data in survey treated in pairwise deletion (see Chapter 3, Section 3.4.3.1.b) to apply PCA, however, the final calculation for PC score requires completed questionnaire with no missing data.

of a_{13} (i.e., $a_{31} = \frac{1}{2} = 0.50$). Using these scores, the pair-wise comparison matrix for Farmer X is presented in Table 5.25.

Table 5.25: The pair-wise comparison matrix (with PCA scores) for Farmer X

Criteria	**U (6)**	**M (9)**	**N (7)**	**P (6)**	**F (5)**	**H (5)**	**S (8)**
U (6)	1.00	0.25	0.50	1.00	2.00	2.00	0.33
M (9)	4.00	1.00	3.00	4.00	5.00	5.00	2.00
N (7)	2.00	0.33	1.00	2.00	3.00	3.00	0.50
P (6)	1.00	0.25	0.50	1.00	2.00	2.00	0.33
F (5)	0.50	0.20	0.33	0.50	1.00	1.00	0.25
H (5)	0.50	0.20	0.33	0.50	1.00	1.00	0.25
S (5)	3.00	0.50	2.00	3.00	4.00	4.00	1.00
Sum	12.00	2.73	7.67	12.00	18.00	18.00	4.67

After developing the comparison matrix for Farmer X, the next step was to calculate the relative importance for each of the seven criteria U, M, N, P, F, H, and S for this farmer. Relative importance was calculated based on the pair-wise comparison matrix in Chapter 3 (Table 3.8) and is presented in Table 5.26.

Table 5.26: The standard matrix and the relative importance of each criterion compared to the other six criteria for Farmer X

Criteria	U	M	N	P	F	H	S	Relative importance
U	0.08	0.09	0.07	0.08	0.11	0.11	0.07	0.09
M	0.33	0.37	0.39	0.33	0.28	0.28	0.43	0.34
N	0.17	0.12	0.13	0.17	0.17	0.17	0.11	0.15
P	0.08	0.09	0.07	0.08	0.11	0.11	0.07	0.09
F	0.04	0.07	0.04	0.04	0.06	0.06	0.05	0.05
H	0.04	0.07	0.04	0.04	0.06	0.06	0.05	0.05
S	0.25	0.18	0.26	0.25	0.22	0.22	0.21	0.23

Table 5.26 shows the weightings that Farmer X reveals for each criterion, regarding his perception of this criterion relative to each of the other six criteria. For example, a feature of Farmer X is that s/he places 34% importance on management practices, while financial and human capitals are each of 5% importance to her/him in their decision making.

However, it is not the same for other farmers in the sample and the distribution of importance between the seven defined criteria is unique for each farmer.

It must be noted that these weights were tested through the use of the principal eigenvector (as outlined in Chapter 3, Section 3.4.3.3). The consistency vector for Farmer X is:

$$\begin{bmatrix} 7.04 \\ 7.17 \\ 7.10 \\ 7.04 \\ 7.05 \\ 7.16 \\ 7.09 \end{bmatrix}$$

This gives a consistency index (CI) = 0.01 and a consistency ratio (CR) = 0.01, which are acceptable, as both meet the criteria that both CI and CR are less than 0.1 in order to demonstrate consistent responses from the farmers. The perceived adaptive capacity index for each of the sample farmers using the PCA weighting is presented in Section 5.6.

5.5.2 AHP for EW scores

In the equal weighting score method, the calculated equal weighted score varied from 1 (less important) to 5 (highly important). The same sample farmer (Farmer X) has EW scores for the seven criterion, uncertainty (U=4), management (M=5), natural (N=5), physical (P=5), financial (F=4), human (H=4), and social (S=4). Using these scores and Table 3.6, the pair-wise comparison matrix (for EW) for Farmer X is presented in Table 5.27.

Table 5.27: The pair-wise comparison matrix (with EW scores) for Farmer X

Criteria	**U (4)**	**M (5)**	**N (5)**	**P (5)**	**F (4)**	**H (4)**	**S (4)**
U (4)	1.00	0.33	0.33	0.33	1.00	1.00	1.00
M (5)	3.00	1.00	1.00	1.00	3.00	3.00	3.00
N (5)	3.00	1.00	1.00	1.00	3.00	3.00	3.00
P (5)	3.00	1.00	1.00	1.00	3.00	3.00	3.00
F (4)	1.00	0.33	0.33	0.33	1.00	1.00	1.00
H (4)	1.00	0.33	0.33	0.33	1.00	1.00	1.00
S (4)	1.00	0.33	0.33	0.33	1.00	1.00	1.00
Sum	13.00	4.33	4.33	4.33	13.00	13.00	13.00

Here again, in developing the pair-wise comparison matrix for Farmer X, the next step was to calculate the relative importance for each of the seven criteria. This relative importance is presented in Table 5.28.

Table 5.28: The standard matrix and the relative importance of each criterion compared to the other six criteria for Farmer X

Criteria	U	M	N	P	F	H	S	Relative importance
U	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
M	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
N	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
P	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
F	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
H	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
S	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Again, the weights (or relative importance) were tested using the principal eigenvector. Using their EW scores, a feature is that they place a relative importance of 23% on each of management practice, natural capital, and physical capital. In contrast their perception is that uncertainty, financial, human, and social capital are of relatively low importance (8%) for their decision making. Once again, for the consistency vector, the consistency index (CI) is 0.00 and the consistency ratio (CR) is 0.00, meeting the criteria for consistency of responses from the Farmer X.

This AHP process was executed for each of the 55 farmers using their individual scores from both PCA and EW weighting methods[31]. The final AHP weights utilised to develop a perceived adaptive capacity and the results for the 55 farmers are presented in the next section.

5.6 Developing a perceived adaptive capacity index

Both the PCA scores and EW scores for each farmer along with their final AHP relative importance ranking were utilised to develop their individual perceived adaptive capacity index (PACI). The calculation of such an index for Farmer X using each of the two weighting

[31] AHP process was not executed for 10 farmers who do not have complete survey, thus, the index was not calculated for farmers ID: 28, 29, 32, 36, 46, 48, 62, 63, 64, and 65.

methods, PCA and EW create the two indices PACIa (based on PCA weightings) and PACIb (based on EW) respectively:

$$\text{PACIa} = (0.09 \times 6) + (0.34 \times 9) + (0.15 \times 7) + (0.09 \times 6) + (0.05 \times 5) + (0.05 \times 5) + (0.23 \times 8) = 7.53$$

$$\text{PACIb} = (0.08 \times 4) + (0.23 \times 5) + (0.23 \times 5) + (0.23 \times 5) + (0.08 \times 4) + (0.08 \times 4) + (0.08 \times 4) = 4.69$$

Two indices then were calculated for each farmer. PACIa for the sample farmers ranged between 5.12 to 7.53 and the PACIb ranged between 3.51 to 4.69. The results are presented in Table 5.29. In Table 5.29, the farmers are ordered according to PACIa index, from highest to lowest.

Table 5.29: The relative importance (%) for the seven criteria and the perceived adaptive capacity indices for each farmer

Farmer ID	U	M	N	P	F	H	S	PACIa	Farmer ID	U	M	N	P	F	H	S	PACIb
7	9	34	15	9	5	5	23	7.53	**7**	8	23	23	23	8	8	8	4.69
26	6	10	10	6	10	36	24	7.45	**50**	9	9	27	27	9	9	9	4.55
4	16	16	9	9	9	35	37	7.37	**45**	9	9	9	27	27	9	9	4.55
12	10	16	10	6	6	27	27	7.11	**20**	10	10	10	28	28	10	4	4.51
50	6	27	16	6	10	10	27	7.11	**26**	10	4	28	28	10	10	10	4.51
19	8	21	8	5	8	8	41	7.03	**6**	5	5	30	30	5	13	13	4.44
3	8	15	8	5	15	8	42	6.91	**10**	12	5	12	34	12	12	1	4.30
23	11	19	11	7	4	19	30	6.83	**13**	12	12	34	12	5	12	12	4.30
13	11	19	19	7	11	3	31	6.82	**22**	12	12	12	34	12	5	12	4.30
22	8	31	8	8	8	5	31	6.81	**53**	12	5	12	34	12	12	12	4.30
20	6	31	6	11	6	19	19	6.81	**21**	13	3	13	34	13	13	13	4.28
21	11	6	11	11	11	20	32	6.77	**1**	14	5	35	14	14	14	5	4.25
37	12	12	20	12	6	6	32	6.72	**12**	14	5	14	35	5	14	14	4.25
10	11	11	19	19	6	6	29	6.65	**18**	5	5	14	35	14	14	14	4.25
53	13	13	21	7	5	7	33	6.63	**34**	14	5	14	35	5	14	14	4.25
45	8	34	8	14	8	8	22	6.60	**37**	14	5	14	35	5	14	14	4.25
61	9	35	9	9	9	4	24	6.46	**61**	14	14	14	35	5	14	5	4.25
17	9	15	15	5	5	15	36	6.42	**58**	14	3	14	14	35	14	6	4.23
42	8	15	15	8	8	8	37	6.41	**31**	16	6	16	36	6	16	6	4.19
6	7	13	13	13	7	24	24	6.33	**38**	16	6	16	36	16	6	6	4.19
15	14	25	14	8	8	5	25	6.24	**54**	16	6	16	36	6	16	6	4.19
8	10	39	10	6	6	10	18	6.23	**5**	6	6	18	38	6	18	6	4.12
34	8	15	26	8	8	8	26	6.19	**9**	18	6	38	18	6	6	6	4.12
56	8	26	8	8	15	8	26	6.19	**56**	14	14	14	14	14	14	14	4.00
25	14	14	14	5	14	14	26	6.16	**17**	16	5	16	16	16	16	16	3.95
16	10	27	16	10	6	6	27	6.11	**19**	5	16	16	16	16	16	16	3.95
59	8	15	15	15	5	15	27	6.09	**23**	16	5	16	16	16	16	16	3.95
44	8	16	16	8	8	16	28	6.03	**42**	16	5	16	16	16	16	16	3.95
30	9	16	16	5	9	16	28	6.00	**11**	18	6	18	18	18	18	6	3.88

Farmer ID	U	M	N	P	F	H	S	PACIa	Farmer ID	U	M	N	P	F	H	S	PACIb
54	16	16	16	9	5	9	28	6.00	**15**	18	6	18	18	18	18	6	3.88
18	9	9	17	9	17	9	29	5.93	**25**	18	6	18	18	6	18	18	3.88
1	10	10	18	6	10	18	30	5.90	**35**	18	6	18	18	18	18	6	3.88
31	10	18	18	10	4	10	30	5.88	**52**	18	6	18	18	18	18	6	3.88
58	31	6	19	6	11	6	19	5.81	**59**	18	6	18	18	6	18	18	3.88
2	19	11	31	6	6	6	19	5.81	**8**	18	18	18	18	6	18	6	3.88
9	11	19	31	6	6	6	19	5.81	**41**	18	3	18	18	18	18	7	3.87
49	11	6	20	11	11	32	11	5.77	**27**	20	7	20	20	20	7	7	3.80
43	12	20	12	6	12	6	32	5.72	**51**	20	7	20	20	7	20	7	3.80
24	10	19	19	6	10	19	19	5.69	**60**	20	7	20	20	7	20	7	3.80
38	19	19	10	10	19	4	19	5.67	**16**	7	7	20	20	20	20	7	3.80
57	11	11	11	11	11	11	33	5.67	**57**	7	7	20	20	20	20	7	3.80
27	19	14	19	17	9	4	17	5.64	**3**	7	7	7	20	20	20	20	3.80
55	20	20	20	11	7	4	20	5.63	**4**	7	7	7	20	20	20	20	3.80
40	12	12	12	6	12	12	34	5.61	**43**	20	10	20	20	6	20	6	3.78
11	11	21	21	6	11	11	21	5.56	**55**	20	10	20	20	20	6	6	3.78
47	11	11	11	6	21	21	21	5.56	**30**	20	7	20	20	4	20	7	3.78
51	12	21	21	7	12	7	21	5.51	**2**	20	4	20	20	7	20	7	3.78
52	12	21	21	7	7	12	21	5.51	**47**	18	3	18	18	18	18	7	3.78
41	12	7	21	5	12	21	21	5.48	**49**	20	4	20	20	7	20	7	3.78
60	22	13	22	7	7	7	22	5.45	**24**	8	8	23	23	8	23	8	3.69
5	12	23	12	12	12	7	23	5.39	**40**	8	8	23	23	8	23	8	3.69
14	12	12	23	12	12	4	23	5.36	**14**	9	4	23	23	23	9	9	3.67
39	4	12	23	12	12	12	23	5.36	**44**	9	9	23	23	4	23	9	3.67
35	13	13	13	13	13	13	25	5.25	**39**	3	9	24	24	9	24	9	3.66
33	15	15	15	8	27	8	15	5.12	**33**	10	4	10	28	28	10	10	3.51

*Note: PACIa is the farmer's perceived adaptive capacity index using PCA scores
PACIb is the farmer's perceived adaptive capacity index using EW scores

Regarding the two indices, it may be a suggestion to group the farmers based on the value of their perceived adaptive capacity index. Consider the first index, PACIa, and for example, separate the farmers into three groups (as defined by the researcher). A farmer's perceived adaptive capacity will be described as "High" if the $\mathrm{PACIa} \geq 7.00$, as "Medium" if $6.00 \leq \mathrm{PACIa} < 7.00$, and "Low" if the $\mathrm{PACIa} < 6.00$. Similarly, the farmers can be grouped based on the second index PACIb into two groups; a "High" perceived adaptive capacity if the $\mathrm{PACIb} \geq 4.00$ and a "Low" perceived adaptive capacity if the $\mathrm{PACIb} < 4.00$.

However, grouping the farmers in this way is not particularly helpful in defining them as adaptive or less adaptive farmers (or farm businesses). Instead, the index is unique for every farmer because it is created from each farmer's perceptions and the relative importance of their perceptions regarding the seven criteria and sub-criteria. The relative importance of

sub-criteria for sample farmers, related to human capital and social capital, is presented in Appendix 5 and Appendix 6.

In Table 5.30 is an example of two farmers, Farmer # 12 & Farmer # 50, with the same PACIa index of 7.11 , but different perceptions and relative importance of the seven dimensions/criteria and indeed of the sub-criteria for human and social capital. This will be further discussed in Chapter 6.

Table 5.30: An example of two farmers with the same index but with different components making up that index

Farmer # 12	*U*	*M*	*N*	*P*	*F*	*H*	*S*
PCA score	6	7	6	5	5	8	8
Relative importance (%)	10	16	10	6	6	27	27

Farmer # 50	*U*	*M*	*N*	*P*	*F*	*H*	*S*
PCA score	5	8	7	5	6	6	8
Relative importance (%)	6	27	16	6	10	10	27

Comparing the seven criteria shows that they rank uncertainty, management practices, natural capital, financial capital, and human capital quite differently. For instance, a feature of Farmer # 12 is that they place 16% importance on management while Farmer # 50 places 27% importance on management practices. On the other hand, physical and social capitals are ranked the same level of importance by both farmers (6% importance on physical capital and 27% importance on social capital).

Therefore, each perceived adaptive capacity index reveals the heterogeneity of each individual farmer's views and perceptions. This unique heterogeneity is important and gives the farmer and other relevant people in the dairy industry a picture of that farmer's perceptions of their farm business and how adaptable it is likely to be in the face of change. The importance of considering the farmers' heterogeneity will be discussed in Chapter 6.

Finally, to choose between the two weighting methods, a correlation test was applied to the two indices PACIa and PACIb. The correlation test shows that the two indices are highly correlated. Pearson correlation coefficient for PACIa and PACIb is 0.986, which is significant

($p < .000$ for a two-tailed test), based on the 55 pairs of indices. Utilising PCA weighting to calculate the scores provides a wider range of index numbers (ranged between 5.12 to 7.53) compared with EW (ranged between 3.51 to 4.69). Moreover, the PCA weighting approach drives a sample-dependent index while the equal weighting (EW) approach drives a sample-independent index. The latter index is more about the farmer as an individual, however, the PCA weighting approach provides a wider range of scores from 1 to 9 with intermediate values between scale for the dimensions resulting in better and more precise pair-wise comparison for the next AHP analysis (See Chapter 3, Tables 3.5, 3.6, and 3.7). Since the two indices are highly correlated, further discussion in Chapter 6 will be based on the PCA weighting approach.

This chapter reported the survey results from the sample of farmers. Presented were the farmer's perceptions around the sources of uncertainty, management practices, and the five capitals. These were used to determine the relative importance the farmer placed on each of these seven dimensions (criteria). This led to the calculation of a perceived adaptive capacity index (using two weighting methods that were shown to be highly correlated) for each farmer. The significance and implications of these findings will be considered further in the discussion chapter that follows.

Chapter 6 : Discussion

6.1 Introduction

This chapter brings together the findings presented in the previous two chapters and reviews them in light of the literature. In this research, a dairy farmer's perceived adaptive capacity index was developed through subjective assessment of the dimensions of perceived adaptive capacity. In addition, developing an index and converting perceived adaptive capacity into a numerical measure via a novel conceptual framework is the main contribution of this study to the literature. Seven dimensions were selected from the literature to analyse the subjective measurement of perceived adaptive capacity which expands previous studies. The seven dimensions are uncertainty, management practices, and the five capitals: natural, physical, financial, human, and social. Uncertainty includes external and internal shocks and stresses that dairy farmers have experienced or expect to experience. The index considers the multi-faceted perceived adaptive capacity via the dairy farmer's perceptions of the seven dimensions and the impact of shocks or stresses on the farm business.

A mixed-methods approach was adopted for this study resulting in a perceived adaptive capacity index for every farmer in the sample, which demonstrates an index rooted in the farmer's perceptions of the dimensions and the relative importance to the farmer of each dimension. The index is discussed in the following section and is contextualised throughout this chapter by drawing on findings from both the qualitative and quantitative research phases, as well as the wider academic literature.

6.2 A new framework for measuring perceived adaptive capacity

The complexities of adaptive capacity which is an attribute of resilient social-ecological systems (SESs) require a framework to be considered when assessing or measuring it (R. Nelson et al., 2007). The framework introduced here encompasses both the five-capitals framework, which originated from the sustainable livelihood framework (Ellis, 2000; R. Nelson et al., 2010) and the decision-making framework, which places the decision-maker at the center of the analysis (Jansen et al., 2013; Nettle et al., 2018; Perrin et al., 2020b). The decision-making framework emphasises capturing risk perceptions (Grothmann & Patt, 2005; Maxwell et al., 2015) and the judgment of the situation and preferences by the

decision-maker to cope with disturbances (Béné et al., 2016b; Jansen et al., 2013). Also, a farmer as the main decision-maker needs to be investigated via their attributes within human capital and their social interactions within their social capital that shapes their judgments (Jansen et al., 2013; Maxwell et al., 2015; Nettle et al., 2018). The five-capitals framework is similar to most previous studies that attempted to measure the adaptive capacity; however, this study has added two other dimensions (uncertainty and management practices) not included in previous studies. These two added dimensions bring the risk perceptions and the preferences of management practices into the framework, which makes the conceptual framework more powerful in the context of farm management, by considering the link between the farmer and the characteristics of the farm business (Darnhofer, 2014).

Furthermore, human capital and social capital are two broad dimensions when resilience or adaptive capacity is studied (Pelling et al., 2008; Yohe & Tol, 2002). Considering these dimensions, as broadly as possible, inside the five-capitals framework is novel. While attributes of human capital in the current research were similar to previous studies (Duranovich, 2015; Reich et al., 2010; Schwarzer & Warner, 2013), there was some expansion of attributes and the questions related to the attributes to reveal more about the individual's perceptions around the human capital dimension when they face disturbances in the context of dairy farming in New Zealand. In addition, the aspects of social capital came from the theoretical literature to see how social networks and connections contribute to adaptive capacity (Adger, 2003; Coleman, 1988; Pelling et al., 2008; Putnam, 2001). The nature of adaptive capacity is place-specific around social capital (Adger, 2003), therefore, to aid the design of the new framework, it was required to consider the aspects of social capital in context and expand some questions within the social capital dimension to reveal and measure the role of social capital for dairy farmers when they face disturbances.

Placing the farmer at the centre of the new framework required a subjective measurement approach aligned with the literature (Maxwell et al., 2015). To do this their perceptions regarding the dimensions of adaptive capacity were used to yield an individual farmer's perceived adaptive capacity measurement. This differs from previous objective measurements of adaptive capacity by R. Nelson et al. (2010), and Pandey et al. (2017), etc., since they were utilising measurable objective variables for the dimensions defined in each

study. In addition, an individual subjective measurement is an improvement in previous studies like Lockwood et al. (2015), who utilised an analytical model to identify perceived adaptive capacity dimensions along with the relative importance of the dimensions. Subjective measurement has a shorter history within the measurement of resilience in general (Jones, 2018), and adaptive capacity in particular (Lockwood et al., 2015). Furthermore, previous subjective measurements studies have focused on qualitative assessment in the literature (Gaillard, 2010; Miller et al., 2010; Twigg, 2009). Quantifying methods of subjective measurements are expanded to some extent in the adaptive capacity literature and are found mostly in resilience measurements. For example, Marshall & Marshall (2007) did make an effort to quantify social resilience and Nguyen & James (2013) utilised a subjective model for household flood resilience. In their adaptive capacity measurement, Lockwood et al. (2015) utilised a psychometric self-assessment approach to identify the dimensions of perceived adaptive capacity. However, they have suggested that the measurement of individual dimensions of adaptive capacity requires improvement. The current study has done this by introducing dimensions to measure individual perceived adaptive capacity with the subjective measurement using a survey featuring Likert scale response items.

The tools used to measure the assessment of an individual's perceptions draw heavily on similar tools in the assessment of psychological resilience, risk perceptions, and subjective well-being (Jones, 2018). The survey design used within this research added to previous studies by including an additional two dimensions, namely uncertainty, and management practices. Uncertainty introduces likely shocks and stresses to understand the farmer's perceptions of the business environment, while management practices cover the importance of management approaches for each farmer. These provided some interesting results, while the relative importance of both the human capital attributes and the social capital aspects for the sample farmers shows some similarities to previous studies, as discussed later in this chapter.

6.3 Perceived adaptive capacity index

The perceived adaptive capacity index was developed using a mixed-methods approach. Qualitative interviews were used to inform the development of a quantitative survey

instrument. Through quantitative analysis of the survey findings, two aggregations of the questions for each dimension were utilised allowing for two different weighting methods for the indices. The weighting methods of Principal Component Analysis (PCA) and equal weighting (EW) made two sets of scores for each defined dimension and the scores provided two different indices for every farmer. The indices reflect each farmer's perceptions of the dimensions and the relative importance of dimensions. The index resulting from the PCA weighting method is sample-dependent, while the index from the EW method is independent of the sample and related to individual perceptions. The sample dependent index provides a wider range of scores from 1 to 9 with intermediate values[32] for the dimensions resulting in better and more precise pair-wise comparison for the AHP analysis. The EW method provides scores from 1 to 5[33]. The intermediate values better demonstrate the difference between the farmers (See Chapter 3, Tables 3.5, 3.6, and 3.7). To cope with this deficiency for EW and have a sample independent score in future studies, one suggestion can be designing the survey based on a 9-point Likert scale. Further discussion will focus on the sample dependant index resulting from the PCA weighting method.

Considering each dimension in the index formula is more important than the overall index value since the perception of the dimension and the relative importance of the dimension allows for the identification of the relative strengths and weaknesses of each farmer. The strengths and weaknesses emerge from subjective measurement and demonstrate how the farmers perceive their situation and that of their business when facing disturbances (Béné et al., 2016b; Jones, 2018). Thus, the information surrounding the farmer's perceptions of each dimension, compared with her/his overall index, provides better insight into their perceived adaptive capacity. For example, when there are two farmers with the same index, this index can evolve in quite different ways related to each farmer's unique perceptions of the dimensions.

Regarding the farmers' perceptions, the greater the concern about uncertainty, the more important the management practices, and the higher the score assigned to each of the five

[32] Intermediate values are described in Table 3.5. The scores include 1, 2, 3, 4, 5, 6, 7, 8, and 9.
[33] The scores include 1, 2, 3, 4, and 5.

capitals result in a higher perceived capacity index. However, perceptions are not equally distributed between the seven dimensions for the farmers. Differing perceptions, also result in different relative importances for each dimension. This is evident where two farmers have the same index, but their perceptions of the dimensions are not the same. An example of this was provided in Chapter 5 for two farmers (# 12 & # 50) who both have $\mathrm{PACIa} = 7.11$ (see Table 5.27). In general, these two farmers expressed greater concern about uncertainty, more importance to the management practices, and a higher score assigned to each of the five capitals. Moreover, as we look in detail at their responses we can see where the differences arise.

Firstly, according to the survey, the structure of their farm business is different. Farmer # 12 is managing two farms located in Northland with a total of 420 cows and 172 effective hectares, the dairy business is classed as system 2. The stocking rate is low (2.1), and workloads are four FTE family members only. They use Once-a-Day (OAD) milking and house some of their cows (100 cows on the second farm). The special feature of the farm is that 90% of the first farm has Kikuyu grass. The farmer is 41-50 years old with 27 years of farming experience. The survey was carried out by the female of the couple managing the farm business. Education level is a Diploma graduate, and they are farm owners in the stage of improving farm performance. Farmer # 50 is also managing two farms located in Hawke's Bay with a total of 1,375 cows and 465 effective hectares, the dairy business is classed as system 3. The stocking rate is high (3.0), and workloads are seven FTE non-family and 0.5 FTE family members. They use OAD milking. There is no special feature for the farm. The farmer is 31-40 years old with 5 years of farming experience. The survey was completed by the male (of the couple managing the farm business. Education level is a degree graduate, and they are also farm owners in the stage of improving farm performance.

Secondly, the index for these two farmers is driven differently by dimensions. The index for Farmer # 12 is "human capital and social capital"- driven, but for Farmer # 50, it is "social capital and management practices"- driven. Human capital is more important for #12 since they rely on family members for the workload and the characteristics of the family members matters for the decision making. The most noticeable difference between family labour and non-family labour can be said that the family members participate in the decision-making process. However, the participation of non-family members may not be considered as

influential as family members except in a situation that trust has been built between the main decision-maker and the non-family staff. Moreover, the attributes of human capital are different for these two farmers, which is discussed later in this section. Management practices are important for Farmer # 50 since the size of the operation is much larger than it is for Farmer # 12. In addition, detail in the survey shows that farmer # 50 utilises a greater variety of management practices than Farmer # 12 utilises.

Furthermore, the difference is clearer when it comes to the human capital attributes and social capital aspects. For instance, although both farmers (# 12 & # 50) place 27% importance on their social capital, they provide differing breakdowns for their social capital score. The most important aspect of social capital for Farmer # 12 is their involvement in the community, generally relying on both bonding and linking social capital. While the most important aspect of social capital for Farmer # 50 is the source of information, and they mostly rely on linking social capital (Table 6.1).

Table 6.1: Examples of different perceptions of the relative importance of social capital aspects

Farmer ID	Value of trustworthy people	Information source	Community Involvement	Bonding	Bridging	Linking
12	16%	20%	32%	7%	12%	13%
50	19%	33%	16%	11%	5%	16%

It may be considered for Farmer # 50 that the size of the operation makes them consider linking social capital more than Farmer # 12. From the qualitative results, it is expected that the banker as a form of linking social capital is very important for most farmers. In addition, other people like the regional council staff are also important for Farmer # 50 nevertheless Farmer # 12 is neutral about the regional council staff. The importance of linking social capital also comes from the main decision maker's views regarding the coming regulations that bring the regional council to the fore for them. Meanwhile, it can be described as a matter of both farm business size and personal view for each farmer.

Regarding the qualitative results that explained regional council staff as a good source of information about the likely regulation change, comparing the same farmers from the same

region can illuminate the matter more. For example, for other farmers in Hawke's Bay (as is Farmer # 50) the regional council staff is not very important for these other farmers from the same region. However, the business size of other surveyed Hawke's Bay farmers is smaller than Farmer # 50 while the business size and stocking rate for Farmer # 50 is also higher than the reported average for Hawke's Bay dairy farmers by DairyNZ (2020b).

Table 6.2: Some information for the surveyed dairy farmers from Hawke's Bay

Farmer ID	Effective hectare	Total cows	Stocking rate
2	150	475	2.7
29	138	385	2.7
50	325+140	975+400	3 and 2.85
Average for Hawke's Bay	231	660	2.86

In addition, comparing the willingness to acquire knowledge for other farmers from Hawke's Bay also demonstrates that acquiring knowledge from other sources (regarding environmental restrictions) is not important. While acquiring knowledge from other sources is very important for Farmer # 50. Thus, they do not think that it is important to be in touch with the regional council (linking social capital) or other farmers (bonding social capital) to get information, while for Farmer # 50 it is important. This comparison illustrates that an indirect impact of farm business size can be predicted in the main decision maker's preference that influences the score of social capital aspects. However, all in all, the overall score of social capital within the conceptual framework of current research mainly results from the individual attributes of the farmer.

Human capital is another multi-faceted dimension that is influential when it comes to decision-making. Other than quantity of human capital, which is the number of people working on the farm, the human capital dimension is important and interesting to examine. It is mentioned above that family members matter for the decision-making process. Looking back into the survey confirms this point with this statement that "The family situation influences my decisions about the farming operation". While Farmer # 12 strongly agrees, Farmer # 50 only agrees with the statement. Moreover, there is another statement that illustrates the situation further: "Family labour is an important part of my farm business".

While Farmer # 12 agrees with the statement, Farmer # 50 is neutral about it. These two statements are embedded in the background questions that cover the influence of family situations on human capital. Interestingly, the relative importance of background shows that it is more important for Farmer # 12 than Farmer # 50. These investigations confirm the aforementioned intuition that the family members participate in the decision-making process. Table 6.3 shows more about the relative importance of other attributes of human capital for the example farmers.

Table 6.3: Examples of different perceptions of the relative importance of human capital attributes

Farmer ID	Background	Locus of control	Self-efficacy	Sense-making	Strategic thinking	Willingness to accept change	Open-mindedness
12	5%	15%	15%	8%	15%	15%	27%
50	4%	16%	9%	9%	10%	26%	26%

Regarding human capital attributes, the distribution of relative importance is different for the two example farmers. Both farmers' perceptions of open-mindedness are very similar, however, Farmer # 50 perceives more willingness to accept change and a slightly higher internal locus of control while the perceptions of the importance of the other four attributes (background, self-efficacy, willingness to accept change, and strategic thinking) are lower than for Farmer # 12. Once again, digging back into the survey illustrates more about how each farmer thinks about themselves. For example, strategic thinking perception is embedded into four statements (see Table 5.13). Comparing these two farmers shows that the relative importance of strategic thinking is higher for Farmer # 12. This comes from the way that she strongly disagrees with the statement "when it comes to business, I like to play it safe". Thus, her attitude is more likely a risk-taking person (Shadbolt & Olubode-Awosola, 2013). There is an assurance of another statement regarding risk-taking, which shows that she believes she can manage almost all uncertainties that occur over the long term. Also, she is strongly confident that she can make "big" decisions correctly and agrees that she prefers to be ahead of regulations. On the other hand, looking into the same statements for Farmer # 50, he is neutral about the statement "when it comes to business, I like to play it safe" which suggests that he is risk-neutral (Shadbolt & Olubode-Awosola, 2013). Although

he declares his neutrality, the other question regarding risk-taking shows that he believes he can manage almost all uncertainties that occur over the long term. In contrast to Farmer #12, he is not strongly confident that he can make “big” decisions correctly, while he strongly agrees that he prefers to be ahead of regulations.

In addition, some questions with more elaboration on disturbances help to get the farmer’s perceptions of themselves and their farm business confronting the changes. Here are two statements from the willingness to accept changes that show:

- Farmer # 12 is neutral when asked if she has thought about exiting dairy farming when environmental issues prevent the business from continuing. In addition, she has not thought about land-use change due to environmental issues prevent the business from continuing.
- Farmer # 50 strongly disagrees when asked if he has thought about exiting dairy farming when environmental issues prevent the business from continuing. In addition, he has thought about land-use change due to environmental issues prevent the business from continuing.

Farmer # 12 is neutral to exit from dairy farming and disagrees to change the land use. Her attempt to collect information from social capital will be less than Farmer # 50 who indicated that they wish to stay in dairy farming.

Therefore, a mixture of responses to the statements demonstrates the farmer’s perception about themselves when they need to decide regarding the changes embedded within the questions. Looking back into the human capital attributes and social capital aspects brings to light that these two capitals are inevitably connected. This is aligned with Jansen et al.(2013) who stated that both human and social capital play important role in decision effectiveness. In this vein, considering all single statements within the survey helps to understand the farmer’s perceptions with more scrutiny. For example, a farmer may not feel a need to get more elaborate extra information about regulations from linking social capital, when they think of themselves as risk-taker and have strong confidence to make big decisions and no tendency to think about fundamental changes for the farm business. However, both the structure of the farm business and the dominant dimensions of the index should be considered simultaneously to comprehend the perceived adaptive capacity.

In the first place, the situation of the business can be used as guidance to interpret the farmer's perceptions. Nevertheless, it is important to consider the farmer's characteristics shown in the perceptions of different dimensions. The index is developed for perceived adaptive capacity through a subjective measurement method, using a survey featuring Likert scale items (Marshall & Marshall, 2007). Besides, looking back into the survey demonstrates that each farmer has specific perceptions about themselves, their connection to other people, and the business environment. This is based on behavioural psychology and social science that individual's perceptions about reality often shape their reactions and decisions (Bandura, 1977; Jackson, 2005). Therefore, as expected demographic characteristics do not play a role in the development of the index and its interpretation. This is in line with Béné et al. (2016b) who found that the demographic characteristics do not have any influence on subjective resilience. Instead, it is the individual's (the farmer's) perceptions of the dimensions that build the index. Farmers with the same index score mentioned earlier are good examples of this, where measurable characteristics such as age and experience show no similarities: Farmer # 12 is 41-50 years old with 27 years of dairy farming experience, while Farmer # 50 is 31-40 years old with 5 years of dairy farming experience.

In addition to the evident situation of the business, each perceived adaptive capacity index contains the individual farmer's perceptions, which are not directly observable and are unique to every farmer. The uniqueness of the index comes from the observation that every farmer evaluates their farm business environment (uncertainties), the management practices, and capitals including themselves and social connections, differently. This is consistent with Maxwell et al. (2015) who stated that the subjective approach is respondent's self-evaluation of preferences and perceptions of their household or self. In addition, the farmers' perceptions of dimensions are important since each farmer relies on their own capabilities and the farm business's capitals to manage disturbances differently and to shape their own adaptive capacity (Darnhofer, 2014). Thus, the focus is on the uniqueness of the individual's perceived adaptive capacity index rather than generalising the index to the population of New Zealand dairy farmers. The index can reveal each farmer's perceptions of every dimension when a farmer is considered as the decision-maker whose perceptions and values can strengthen or weaken the resilience of the farming

system in terms of adaptive capacity (Darnhofer et al., 2016). Therefore, the index and the relative importance of dimensions are not generalisable according to the observable items such as the region or the other characteristics of the farm business. Instead, the construction of the index is invaluable to comprehend the perceived adaptive capacity. It may be helpful to investigate two farmers from the same region and examine their responses to the detailed dimensions of their index, as done in the next section.

6.3.1 Comparing two farmers from the same region

The focus on the construction of the index here is shown with a comparison between two farmers from the Waikato region who have the same index, $\mathrm{PACIa} = 5.56$. First, a brief look at the farm business structure shows that the structures of their farm businesses differ. Farmer # 11 is an owner-operator of a farm business with an 800 cows farm area, while Farmer # 47 is an equity partner (operator and/or non-operator) of three farm businesses with 2,650 cows farm area. Second, their perceptions of the seven dimensions are not the same. In general, compared to a farmer with a high index (for example, $\mathrm{PACIa} = 7.11$), these two farmers show low concern about uncertainty, less importance for management practices, and a lower score assigned to each of the five capitals. Table 6.4 demonstrates the relative importance of dimensions for the example farmers.

Table 6.4: An example of two farmers from the same region with the same index but with different components making up that index

Farmer # 11	**U*	*M*	*N*	*P*	*F*	*H*	*S*
PCA score	5	6	6	4	5	5	6
Relative importance (%)	11	21	21	6	11	11	21
Farmer # 47	*U*	*M*	*N*	*P*	*F*	*H*	*S*
PCA score	5	5	5	4	6	6	6
Relative importance (%)	11	11	11	6	21	21	21

*U=Uncertainty, M=management practices, N=Natural capital, P=Physical capital, F=Financial capital, H=Human capital, S= Social capital

Farmer # 11 is mostly focused on management practices, natural capital, and social capital (21% each). This is because of the wider range of management practices that the farmer utilises, the higher score of propensity to natural capital conservation, and the higher importance score for social capital. However, Farmer # 47 is mostly focused on financial capital, human capital, and social capital (21% each). The relative importance of social capital is the same for both farmers. However, it is constructed from different social capital aspects for each farmer, as demonstrated in Table 6.5.

Table 6.5: Example of different perceptions of the relative importance of social capital aspects (two farmers from the same region)

Farmer ID	Value of trustworthy people	Information source	Community Involvement	Bonding	Bridging	Linking
11	24%	24%	24%	8%	8%	13%
47	20%	33%	20%	11%	11%	5%

Farmer # 11 puts the same importance on the value of trustworthy people, information source, and community involvement (24%). However, Farmer # 47 puts higher importance on the source of information. Considering both farm business sizes, it may be expected for Farmer # 47 that the size of the operation will make them consider linking social capital more than Farmer # 11, however, this is not the case. One reason may be the impact of ownership structure for Farmer # 47, who is an equity partner (operator and/or non-operator). They put less importance on linking social capital. The personal characteristics of the farmers were also considered. In this vein, the importance of human capital is not equal for the two farmers, and the attributes of human capital are not equally distributed either (Table 6.6).

Table 6.6: Example of different perceptions of the relative importance of human capital attributes (two farmers from the same region)

Farmer ID	Background	Locus of control	Self-efficacy	Sense-making	Strategic thinking	Willingness to accept change	Open-mindednes
11	5%	14%	8%	15%	8%	25%	25%
47	3%	16%	11%	19%	13%	19%	19%

Farmer # 11 has the higher relative importance of 'willingness to accept change' and 'open-mindedness' compared to Farmer # 47. While, Farmer # 47 has a higher locus of control, self-efficacy, sense-making, and strategic thinking. Therefore, it is expected that a farmer with less open-mindedness will consider fewer people from outside the farm business. In addition, less importance for 'willingness to accept change' is another reason for less importance of linking capital.

The similar viewpoint of uncertainties, management practices, and five capitals lead to a similar index. However, maybe it is more like a fingerprint since there are no two farmers with exactly the same viewpoints. The individuality of the index may be fine to industry people or to an advisor who works with the farmers individually. It is helpful to consider whether the perceived adaptive capacity is aligned with the business performance when a desirable or undesirable disturbance takes place. A gap between perceptions and real performance can cause the lack of adaptive capacity when a farmer overestimate or underestimate affecting dimensions. However, it is not easy to make policies by considering a population one by one. Thus, when the questions for each dimension present the farmer's perceptions of each dimension, a policymaker will look for similarities and differences between the farmers to predict their reaction or adaption facing new policies. General remarks about sample farmers' perceptions are useful in the policymaking process to predict the farmers' adaptive capacity.

6.4 General remarks about farmers' perceptions

The dimensions of New Zealand dairy farmer's perceived adaptive capacities here are seen in the way that their perceptions of uncertainty, of the management practices, and of the business's capitals are revealed. Remarks are discussed in this section related to the dimensions of uncertainty, management practices, human capital attributes, and social capital aspects.

Firstly, it was investigated how a dairy farmer, as the main decision-maker, in New Zealand has experienced or experiences a range of disturbances including shocks and stresses. Some shocks and stresses have been introduced in the literature (Meuwissen et al., 2019) such as a sudden change of input or output price (as a shock) and ongoing regulation changes (as a stress). However, further research was required to find out more about the disturbances

that dairy farmers in New Zealand experience. A list of disturbances was introduced in previous studies in New Zealand (Duranovich, 2015; Shadbolt & Olubode-Awosola, 2013). Findings from the qualitative phase of this research show both additional uncertainty and management practices. In this vein, the dairy farmers in this study experienced some common disturbances due to external changes such as price shocks or regulation changes. Also, it was shown that each farmer experiences some disturbances specific to them due to their farm location, age, goals, financial expectations of the business, and ownership structure. For example, the financial expectations of those farmers near retirement differ from young farmers who are planning to expand their business. Therefore, younger farmers intending to expand their business will take on more debt, which makes them more likely vulnerable when an external shock like a price drop occurs. As such, younger farmers rely more on family labour and bear a higher workload. This situation makes them more likely vulnerable to an internal shock like the illness of a working family member. Therefore, although it is not directly measurable, all farmer's perceptions of their business environment are indirectly shaped by the circumstances of their business and the external and internal disturbances that they experience or think they may experience.

Secondly, the other dimension of perceived adaptive capacity introduced here was the management practices that dairy farmers apply to cope with these disturbances. This dimension is mentioned by Lockwood et al. (2015) as management style. The farmer's perception of each particular management practice shows the importance of that practice to them. A list of management practices was introduced in previous New Zealand studies such as maintaining feed reserves, not producing to full capacity and managing debt levels (Duranovich, 2015; Khatami et al., 2019). These were used here and based on the findings from the qualitative phase, other management practices were added such as having off-farm investment and having a health & safety plan.

Thirdly, every farmer sets their goals based on the five capitals of their farm business. The farmers' perceived adaptive capacity includes their perceptions of the importance of these capitals to face disturbances both desirable and undesirable. These perceptions were explored by asking questions in which embedded common disturbances or most probable disturbances in the New Zealand dairy farming environment would affect their business. Designing the survey was an important part of the subjective assessment, in which the

context was considered and the questions allowed the respondents to self-evaluate according to the contexts and conditions that they are in (Béné et al., 2016b; Jones, 2018; Lockwood et al., 2015; Marshall & Marshall, 2007). The design of the survey statements and questions was presented in Chapter 4. In previous studies, the two dimensions, human and social capital are considered of equal importance to the other three capitals within the five-capitals framework when assessing or measuring adaptive capacity (R. Nelson et al., 2010) or perceived adaptive capacity (Lockwood et al., 2015). Therefore, the expansion of these two capitals in the design of the survey better represented the sample farmers' perceptions of these capitals and demonstrated interesting similarities to and differences from previous studies.

6.4.1 Perceptions of uncertainties

A list of uncertainties was provided to the farmers using previous dairy farming studies in New Zealand (Duranovich, 2015; Khatami, 2022; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013) and adding to these from the findings of the qualitative phase of this study. The highest uncertainties demonstrate which disturbance is of more concern to the surveyed farmers. Following this, the more important management practices associated with these disturbances help farmers to adapt to changes. Table 6.7 shows the five highest perceived threats or opportunities identified by the sample farmers.

Table 6.7: Comparison of the top-five ranked sources of uncertainty with previous recent studies

Threat	Current study ranking	2015 **	2013 *	Opportunity	Current study ranking	2015 **	2013 *
Staff and/or personal injury	1	-	-	Technological change	1	1	1
Input prices and availability	2	3	1	Business relationship	2	2	5
Availability of quality labour	3	4	4	Global supply and demand for food	3	3	2
Local body laws and regulations	4	1	2	Pasture/crop/animal health	4	6	4
Government laws and policies	5	2	3	Skills & knowledge of those associated with the business	5	4	3

**Duranovich (2015)- *Shadbolt & Olubode-Awosola, (2013)

In previous studies, the importance of these sources has been considered. Shadbolt & Olubode-Awosola, (2013) and Duranovich (2015) list the same top sources of risk but with a slightly different ranking. The highest-ranked uncertainty recognised as a threat for the sample farmers is the internal change of staff and/or personal injury, which was added to the list of risks in this study based on the findings from the qualitative phase. Interestingly, it is perceived as the highest source of uncertainty (or threat) for the sample farmers. This may be a consequence of the legislation of the Health and Safety at Work Act 2015[34] that has created a new source of uncertainty for dairy farmers. In addition, considering the qualitative phase, the farmers who have experienced a shock due to personal loss or injury can describe the negative impact of the disturbance on their business (see Chapter 4, Section 4.3.1.2).

A major source of uncertainty in the production period is those related to market uncertainties including input prices and availability of inputs (Boehlje et al., 2005; Pinochet-Chateau et al., 2005). Input prices and availability are considered the second source of threat by the sample farmers, which is consistent with previous studies. Availability of quality labour is the third overall source of threat for the sample farmers in the current study, however, it is ranked fourth in several previous studies (Duranovich, 2015; Shadbolt & Olubode-Awosola, 2013). Labour availability is also an important external stress for three of four case farmers in the qualitative phase (see Chapter 4, Section 4.3.2.1). The reasons for the shortage of dairy farming labour in New Zealand were introduced by Eastwood et al. (2020) and include changes to the traditional dairy career path. This traditional path begins with contract milking and sharemilking and ends up with farm ownership. Quality labourers and the newer generation are reluctant to follow this traditional path when it is possible for them to be well-paid professional farm managers, rather than striving for farm ownership. Also, a change to the expectation of work for new generations, caused by greater urbanisation of labour pools combined with the physical isolation of dairy farms, makes the availability of labour (or quality labour) complex and difficult (Eastwood et al., 2020). In addition, regulatory sources of uncertainties; local body laws & regulations, and government laws & policies have been increasing sources of uncertainty in recent years (Boehlje et al.,

[34] https://www.legislation.govt.nz/act/public/2015/0070/latest/DLM5976660.html

2005). Observing them among the top five highest uncertainties as threats shows that New Zealand dairy farmers are aware of the disturbances that arise from the local and national economies and the changing global situation (Duranovich, 2015; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). The qualitative findings in this study shows the same awareness and perceptions of ongoing changes in regulations for the four case farmers (see Table 4.10).

In terms of opportunities, a new technological change is seen by this group of farmers as a real potential opportunity. Technological change influences competition in the farming business since it helps business development in the production process (Gray et al., 2004; Olson & Boehlje, 2010). In the same way, technological change has been introduced as an important source of uncertainty with a positive impact on New Zealand dairy farmers in previous studies (Duranovich, 2015; Shadbolt & Olubode-Awosola, 2013). The uncertainty ranked second as an opportunity is the business relationship (with input providers) for the sample farmers. This originates from the threat of input prices and availability since currently, dairy farming in New Zealand is relatively intensive in using higher proportions of supplementary feed (Ma et al., 2019). Thus, farmers try to maintain a good relationship with input providers and see this as an opportunity when facing disturbances such as weather variability resulting in a pasture deficit. Aligned with this, findings from the qualitative phase demonstrate that the farmers located in regions with variable weather, identify maintaining a good connection with input providers as an important opportunity to cope with disturbances. Uncertainty around changes in global supply & demand for food is seen as the third opportunity. Consistent with this is Shadbolt & Olubode-Awosola (2013) who also identified global supply and demand for food as providing the most benefit to the dairy farm business in the long term. This is because the dairy farmers are aware of New Zealand's situation as one of the world’s largest dairy exporters (McGiven, 2016). Pasture/crop/animal health, and skills & knowledge of those associated with the business are two other uncertainties that the farmers believed would provide opportunity. Where pasture/crop/animal health is important to have a productive business, Shadbolt & Olubode-Awosola (2013), also, introduced skill & knowledge of those associated with the business as one of most beneficial option for dairy farmers. Moreover, skills and knowledge

of those associated with the business lead to labour saving and management improvement of farming (Jago et al., 2013).

A further difference between this study and previous studies is the time frame presented to the farmers for consideration around risks and uncertainties. The sample farmers' perceptions of the changing environment were asked for the coming five years to see how farmers perceive strategic risks. Asking their perceptions of uncertainties for upcoming years is important when the "bouncing forward" concept is the core of attention for adaptive capacity (Manyena et al., 2011), and prevention and preparedness for disturbances are embedded in the survey (Jones, 2018; Maxwell et al., 2015). The time frame considered in Shadbolt & Olubode-Awosola (2013)'s study was within the farming season and over the next 5 to 10 years. However, Duranovich (2015) asked about dairy farmers' perceptions of changing environment in the last 10 years. Embedding changes for the coming five years in the survey revealed how farmers perceive strategy more than operational and tactical management practices.

6.4.2 Perceptions of management practices

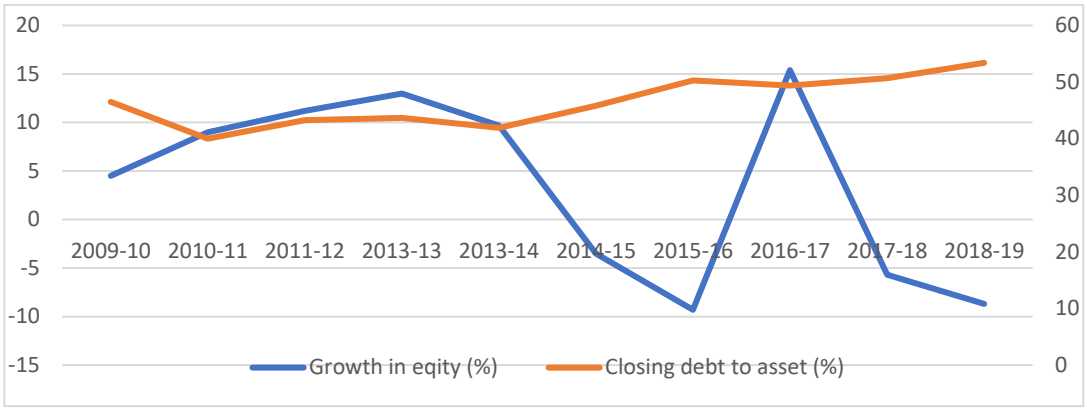
To capture the other dimension of perceived adaptive capacity, namely management practices, it was necessary to ask questions regarding the importance of common management practices. Management style particularly, with change orientation has been introduced as a dimension of perceived adaptive capacity by Lockwood et al. (2015). The common management practices for dairy farmers in New Zealand have been listed and slightly changed from previous studies (Duranovich, 2015; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). The list in this study was chosen from the previous studies in New Zealand with some modifications regarding some current changes in the business environment and the intention of the current research. For example, "having more than one type of animal or other enterprises on-farm" was omitted. Instead, "having a health & safety plan and keeping health and safety manuals up to date" was added to the list. The previous studies pre-dated the workplace health and safety legislation of 2015 which came into force in April 2016. An example of modification, "maintaining feed reserves" (from Duranovich, 2015) was modified to "having feed reserves on the farm", because maintaining feed reserves assumes that the farm already has feed reserves.

However, the intention of the current study was to recognise the importance of management practices as a dimension of perceived adaptive capacity. Therefore, when a farmer shows that they have feed reserves on the farm and how it is important to them, this contributes to their perceived adaptive capacity measurement.

The five most common management practices for the sample farmers are: 1) having feed reserves on-farm, 2) managing debt levels, 3) keeping debt low or increasing equity, 4) assessing strengths, weaknesses, threats, and opportunities of the farm business, and 5) having a health & safety plan and keeping health and safety manuals up to date.

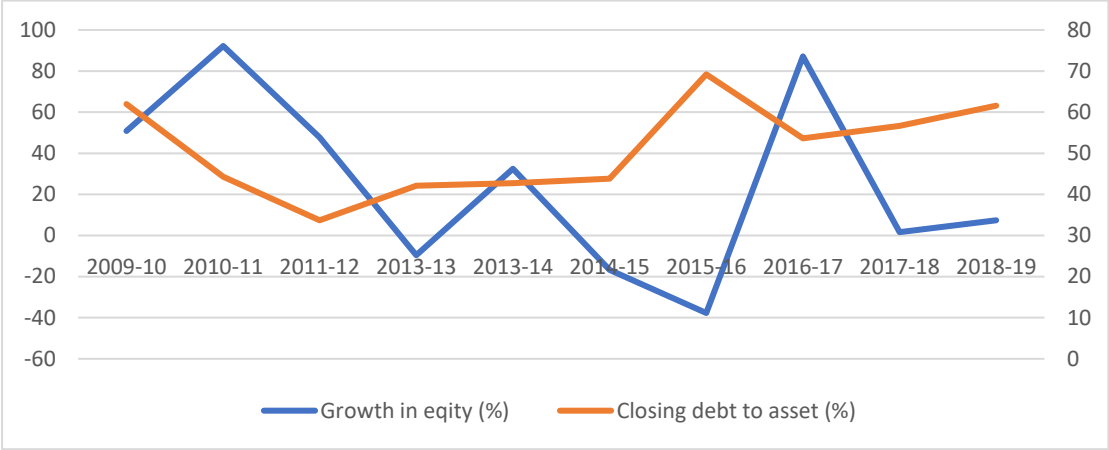
Having feed reserves on-farm optimises feed efficiency for New Zealand dairy farming (Wales & Kolver, 2017) and managing debt levels demonstrates the farmers' awareness of the reality of farming in a turbulent economic environment where they need to manage their financial situation with care (Khatami et al., 2019). These two management practices are in the top five management practices for the current study as they are in other studies (Duranovich, 2015; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2013). In addition, debt management had been identified as the most important risk management strategy for dairy farmers in New Zealand (Duranovich, 2015; Khatami et al., 2019; Pinochet-Chateau et al., 2005; Shadbolt & Olubode-Awosola, 2016). The sample dairy farmers show that they tend to keep debt levels low or increase their equity along with managing their debt level, which is introduced as a sign of a resilient farm by Darnhofer (2010). This may be a result of the ownership structure for the sample farmers where 62% are owner-operators and 17% are equity partners, while 21% are herd-owning sharemilkers. According to Pinochet-Chateau et al. (2005) sharemilkers are more likely to operate with a higher debt level than owner-operators. In this vein, DairyNZ (2020a) shows that the level of debt to asset ratio for owner-operators was 53.4% at the end of the season 2018-19 while there was decreased growth in equity (-8.7%). Also, the level of debt to asset ratio for sharemilkers was 61.6% while growth in equity for them was a little higher than the previous season, 7.4%. Although the farmers place a high importance on managing debt levels and keeping debt low or increasing equity, data from industry shows that their reality does not follow their perceptions, when debt is growing in a faster rate than equity (DairyNZ, 2020a).

Figure 6.1: Capital structure and wealth creation for owner-operators



Source: DairyNZ (2020a)

Figure 6.2: Capital structure and wealth creation for herd-owning sharemilkers



Source: DairyNZ (2020a)

The management practice ranked fourth in importance for the sample farmers is 'assessing the strengths, weaknesses, threats, and opportunities of the farm businesses. This management practice was introduced as a strategic risk management response by Pinochet-Chateau et al. (2005). Also, Boehlje et al. (2005) stated that strategic risks are multidimensional and more external, such as regulatory risks that require more adaptability to be managed. Thus, appearing within the five top management practices for the sample farmers is a sign that the dairy farmers tend to be more adaptable to the business environment. Among these five management practices, the fifth is the new addition to the list, which is having a "health & safety plan and keeping health and safety manuals up to date". This is a direct result of the new health & safety legislation in 2015 and was not

unexpected when “staff and/or personal injury” was identified as the first ranked source of uncertainty for the sample farmers.

6.4.3 Perceptions of human and social capitals

The human capital and social capital dimensions are important precursors to evaluating the situation and making a decision (Jansen et al., 2013). These two capitals are calibrated and include defined attributes and aspects, and it is here where there is more diversity between the sample farmers and which impacts their perceived adaptive capacity index. All these differences highlight the uniqueness of the index to each farmer. The difference between farmers’ perceptions is important and should be considered since it gives the farmer and other relevant people in the dairy industry a clearer picture of that farmer’s perceptions of their farm business and how adaptable it is likely to be in the face of change.

The design of new questions around human and social capital were compared with those in the literature (Babaei et al., 2012; Coleman, 1988; Connor & Davidson, 2003; Duranovich, 2015; Putnam, 2001; Reich et al., 2010). The relative importance of human capital attributes for the sample farmers shows that the two attributes perceived to be the most important are “willingness to accept change” and “open-mindedness” while the attribute perceived to be the least important is “background”. Compared to Duranovich (2015), in which “self-efficacy” was the most important attribute, and the “willingness to accept change” the second most important attribute for the resilient dairy farmers, the surveyed farmers in this study, show similarity regarding “willingness to accept change”. However, “open-mindedness” was not very important for Duranovich’s (2015) study (ranking the fourth), while it is highly important for the surveyed farmers of this study, with the highest mean and the lowest coefficient of variation. Table 6.8 shows the statistics regarding the attributes of human capital.

Table 6.8: The relative importance of the human capital attributes to the sample farmers

Human capital attribute	Min	Mean	Max	SD	CV
Open-mindedness	13%	26%	37%	0.05	19%
Willingness to accept change	4%	24%	37%	0.05	21%
Sense-making	4%	10%	20%	0.03	30%
Self-efficacy	4%	13%	26%	0.06	40%
Strategic thinking	1%	10%	25%	0.04	40%
Locus of control	3%	11%	33%	0.05	45%
Background	3%	6%	19%	0.03	50%

Looking back to the literature, “willingness to accept change” is described as a key attribute of a resilient person (Connor & Davidson, 2003; Coutu, 2002). Particularly, the acceptance of the uncertain reality of agriculture or willingness to accept changes is linked to the farmer's ability to learn and is related to their adaptive capacity (Boxelaar et al., 2006). Likewise, there is a positive relationship between “open-mindedness” and a “resilient personality” (Darnhofer, 2010; Webb, 2013). In addition, sense-making is an attribute directly linked to adaptive capacity since it is related to processing information in situation of change (Duranovich, 2015). Moreover, a positive link has been identified between perceived self-efficacy and people’s resilient personality (Coutu, 2002; Reich et al., 2010; Schwarzer & Warner, 2013). Although the “locus of control” and “strategic thinking” are introduced as influencing attributes of a resilient and adaptive person (Darnhofer, 2010; Skodol, 2010; Walker & Salt, 2006), they are relatively of lower importance for the surveyed farmers.

Drawing upon the literature, the mentioned attributes of human capital contribute to a resilient personality. It is not only by one higher attribute that a person becomes to be a resilient or adaptive, but a combination of the attributes reveals a resilient or an adaptive person. Three important attributes “willingness to accept change”, “open-mindedness”, and “sense-making” for the sample farmers demonstrates their tendency to enhance their adaptive capacity. In this vein, Boxelaar et al. (2006) stated that “willingness to accept change” is linked to the ability of learning, thus it increases a person’s adaptive capacity. As such, “open-mindedness” is related to person’s acceptance of being co-learners about multiple legitimate outcomes (Rogers et al., 2013). Thus, it also increases a person’s adaptive capacity. In addition, “sense-making” is related to the flow of information and enhance adaptive capacity where it helps when managing risk and uncertainty through goal setting, problem solving, and perceptions of business environment (Duranovich, 2015). Therefore, sense-making directly helps increase adaptive capacity. Furthermore, the design of the questions can influence the way that a farmer answers the questions. The questions of the current survey have been elaborated compared to the previous study by Duranovich (2015).

Finally, the sample farmers in this study revealed the relative importance of different aspects of social capital when they face disturbances. Table 6.9 demonstrates the relative importance of social capital aspects for the sample farmers.

Table 6.9: The relative importance of the social capital aspects to the sample farmers

Social capital aspect	Min	Mean	Max	SD	CV
Value of trustworthy people	11%	22%	38%	0.06	27%
Information source	10%	27%	41%	0.08	30%
Community involvement	10%	23%	36%	0.07	30%
Bridging	4%	9%	15%	0.03	33%
Bonding	4%	8%	17%	0.03	38%
Linking	5%	10%	21%	0.04	40%

Social capital is important as "value of trustworthy people" since it is the value of different people that influence decision-making (Lin, 1999). It is important for the surveyed farmers likewise the case farmers in qualitative phase since they need a range of supports when they face disturbances. For example, facing an undesirable disturbance like a fall in milk price, case farmers mentioned the emotional support. In addition, the other important aspect of social capital is "information source" for surveyed farmers, which is consistent with studies that highlight the knowledge and information flow through social capital (Fisher, 2013; Jansen et al., 2013; Lin, 2001). According to the literature social capital plays an important role in providing a useful source for information dissemination and increasing access to information and knowledge (Coleman, 1988; Fisher, 2013; Katungi et al., 2008; Mills et al., 2011; Quan-Haase & Wellman, 2004). This is also important when it comes to decision-making, social connections provide wider information for the decision-makers (Jansen et al., 2013). The more social relationships, the more information flow concerning the decision situation (Heavey et al., 2009). However, it is not easy to say more connections mean more reliable information since the more influential information depends on how much trust exists within the relationships (Bouma et al., 2008; Hunecke et al., 2017). Trust is a cognitive concept embedded in social capital and is difficult to measure (Bouma et al., 2008). Likewise, social capital as a source of information has been emphasised by the findings of the qualitative phase, with the case farmers noting the importance of the information that they can acquire from different channels such as discussion groups, the Internet, and regional council staff. Social credentials or involvement in the community provides access to resources through social networks and relations (Lin, 1999) where community involvement is also important for surveyed farmers. The involvement in the community is a way to expand their bridging and linking social capital.

Responding to the survey, the importance of bonding, bridging, and linking is slightly different. However, coefficient of variation for bridging is lower than the other two, which shows the relative importance of bridging for surveyed farmers is less varied than bonding and linking. In contrast, coefficient of variation for linking importance is higher than the other aspects. As Arnott et al (2021) stated, farmers with more linking social capital are more likely to work with government officials to adapt to policy change. The variation of linking importance may be a sign that dairy farmers are less likely to accept government policy and adaptive capacity. According to the literature, these three forms of social capital influence the ability of individuals to respond to disturbances (Babaei et al., 2012; Claridge, 2018; Klerkx & Proctor, 2013; Poortinga, 2012). However, the importance of bonding, bridging, and linking social capital depends on every individual's perception of each. The importance of the linking form of social capital when operating in a turbulent environment was emphasised in the qualitative phase findings. The four case farmers noted the importance of bankers and the importance of keeping a good relationship with bank managers, particularly in the event that they may face, for example, a downward shock in global milk prices. The case farmers mentioned that those people in positions of power over the business are a good source of information, especially about regulation. However, in a bigger sample it is less important than bridging and bonding.

The combination of importance for the "bridging" form of social capital and for "value of trustworthy people" highlights the role of social capital for surveyed farmers when they face disturbances, they turn to trustworthy people in bridging type social capital. In addition, the importance for "the source of information" can be interpreted as a sign of surveyed dairy farmers' tendency to be ahead of disturbances before they happen, in order to capture the opportunities. Emphasised in the qualitative results, all the case farmers mentioned the ongoing change in regulation as stressful and they try to get more information about this stress. However, it is not the case for all the farmers and more investigation shows that the business situation, ownership structure, and the farmer's human capital attributes also have impacts on how the farmer sees the aspects of social capital as useful sources to adapt to changes.

6.5 Summary

The findings of this study support the improvement of measurement for individual dimensions of adaptive capacity as suggested by Lockwood et al. (2015). The literature review in Chapter two outlined the previous frameworks to study adaptive capacity. The most common framework used in adaptive capacity studies is the Sustainable Livelihood Framework (SLF) in which the five capitals have been emphasised. Moreover, the role of decision-makers in SESs and livelihoods are inevitably significant, which is why this study focused on people who are influential in the decision-making process. In addition, there have been two methods assessing or measuring of adaptive capacity; objective and subjective. In the objective method, a researcher can look for measurable variables as surrogates to indicate adaptive capacity, which has been under debate since choosing appropriate surrogates is difficult. In addition, to use an objective method, a researcher can look for some measurable variables or indicators to construct an index, in which defining a framework is very important. In a subjective method, the focus is on the perceptions of the person who makes the decisions.

This study combined the findings of framework definitions and the subjective method. It began by using qualitative methods to analyse four case studies focusing on the perceptions of the decision makers for the farming business. Then setting up seven-dimension framework, an index was created for perceived adaptive capacity based on the decision makers' perceptions. The framework of seven dimension with an expansion of two influential capitals (human and social capitals) for the construction of the index, and the index itself contributes to the literature. It builds on a range of studies that considered subjective tools to assess resilience or resilience attributes in different fields (Bénébet al., 2016a; Béné et al., 2016b; de Villiers et al., 2014; Jones & Tanner, 2017; Lockwood et al., 2015; Nettle et al., 2018; Nguyen & James, 2013; Perrin et al., 2020b).

Moreover, designing a survey based on subjective measures was an important part of this research. The context was considered to design questions where a farmer can self-evaluate according to the context and conditions that they are in. The expansion of the human and social capitals in the design of the survey enabled the sample farmers to reveal their perceptions in more detail, providing more in-depth understanding of each farmer's

perceived adaptive capacity. The discussion demonstrated that an individualistic consideration of the perceived adaptive capacity highlights the importance of every farmer's unique perception. These perceptions within the introduced framework shows a picture of farmer’s mind. Having a picture of farmer’s mind along with monitoring reality will help an advisor to see how much their mind is aligned with their action. Since a gap between perceptions and reality can cause a lack of adaptive capacity. The following chapter provides more detailed consideration of implications of study findings. In addition, the limitation of study and suggesting areas for further research.

Chapter 7 : Conclusion

7.1 Introduction

This study set out to define the dimensions of dairy farmers' perceived adaptive capacity and to develop a tool to measure this capacity. Furthermore, this research sought methods to identify and use the dimensions of perceived adaptive capacity to develop an index. The concluding chapter summarises the key findings that have emerged from this study. Regarding the research findings, several considerations for dairy farmer's perceived adaptive capacity are put forward. The chapter also explores some of the methodological considerations and limitations of the study, including the usefulness of the mixed methods approach in studying the perceived adaptive capacity concept and measurement. Possible directions for future research are also presented.

7.2 Key findings

After positioning the study within the literature, this study has introduced a novel framework to explore the perceived adaptive capacity of New Zealand dairy farmers facing disturbances, including shocks and stresses. The following research questions were developed in order to guide the data collection and analysis:

- What are the dimensions of New Zealand dairy farmers' perceived adaptive capacity when facing external or internal pressures?
- Can an index be developed to measure a dairy farmer's perceived adaptive capacity?
- How do the dimensions affect the perceived adaptive capacity index?

The following objectives were met to address the above questions:

- Designed a conceptual framework to describe a New Zealand dairy farmer's perceived adaptive capacity when facing challenges due to disturbances.
- Investigated dairy farmer perceptions of disturbances; shocks and stresses in the context of a dairy farming business in New Zealand.
- Identified management practices affecting the utilisation of the capitals of a dairy farming business.

- Developed a measurement tool for New Zealand dairy farmers' perceived adaptive capacity.

Based on the research questions, some key findings have been identified. With respect to the first research question, although some work has been done to understand the adaptive capacity concept in different fields, there is limited research on perceived adaptive capacity both in understanding and measurement. The conceptualisations of perceived adaptive capacity put forward by the five-capitals theory, from the sustainable livelihood framework (SLF), have been explored and some shortcomings were noted, (the five capitals are natural, physical, financial, human, and social). While the conceptualisations of the five capitals make important contributions to the understanding of adaptive capacity, no particular theoretical interpretation has been introduced that is appropriate for exploring the human and social capitals within the five-capitals framework. Literature shows that these two capitals are influential for the perceived adaptive capacity of farmers. While the five capitals are important, the influence of the business environment on the farmer's perceived adaptive capacity is also important, which has been less explored and was a shortcoming in the literature. Similarly, the role of management practices within the business influencing a farmer's perceived adaptive capacity has been less explored. Therefore, a new framework was introduced considering seven dimensions of New Zealand dairy farmers' perceived adaptive capacity when facing external or internal pressures. These seven dimensions are the uncertainties present in the business environment, five capitals, and management practices.

In response to the second research question, the introduced framework provides a lens through the various dimensions that can be used to design a tool in order to assess a farmer's perceived adaptive capacity, with a focus on those disturbances that are common for dairy farming in New Zealand. The perception of the dimensions relates exclusively to each farmer's view of the uncertainties related to the business environment, of their five capitals, and of what management practices they can use to cope with these disturbances. In addition, the farmers' responses show that the highest sources of uncertainties are aligned with those identified in previous New Zealand studies (Duranovich, 2015; Shadbolt & Olubode-Awosola, 2013) such as input prices and availability, availability of quality labour, local body laws and regulations, and government laws and policies. Moreover, the most important management practices for the farmers are closely aligned with the previous

studies, such as having feed reserves on-farm, managing debt levels, and keeping debt low or increasing equity.

Farmers consider government policies and regulations as a threat to their business. Additional threats to the business are staff and/or personal injury, and local body laws. This has important implications in relation to government policy that increasingly emphasises environmental sustainability and resource management. These policies put more pressure on dairy farmers, highlighting the turbulent business environment they face (Gray et al., 2008; Shadbolt et al., 2011). This study has shown that the nature of the turbulent environment needs to be taken into account when designing a tool to measure a dairy farmer's perceived adaptive capacity. The turbulent environment is considered in the context of uncertainties and management practices dimensions, and the five capitals, in which the common disturbances are embedded.

Answering the third research question, considering the index development from seven dimensions, this study utilised two weighting methods to weigh every question in the survey. The insight into the farmers' perceptions highlights the uniqueness of each farmer's perceived adaptive capacity index. For example, two farmers with the same index may have quite different perceptions of the importance and influence of the seven dimensions on their farm business in terms of adaptive capacity. In addition, differences in the human and social capitals for each farmer shows more about the uniqueness of the index for each individual farmer.

7.3 Implications of this research

This research can be implemented for advisors within the dairy industry. Firstly, each farmer's perceptions need to be acknowledged before considering their business performance. On one hand, the relative importance of different dimensions illustrates whether the farmer perceives a dimension as more important than any other. On the other hand, their performance shows the consistency between the farmer's perceptions and his/her actions. A gap between perceptions and actions can result in a lack of adaptive capacity and ultimately an inadvertent transformation for the business in the turbulent environment.

Secondly, revealing the reality of performance of those dimensions that can be measured objectively (like natural, physical, and financial capitals) can be useful for the farmers. Some

farmers perceive themselves as good at natural capital conservancy, physical capital improvement, or financial performance while the reality may show that their perceptions are incorrect. Considering the detail of the perceived adaptive capacity can show a picture in the mind of the farmer whether their action is consistent with their perceptions. Therefore, a collaboration between an advisor and the farmer can go deeper to correct either perceptions or actions to achieve the desired outcome.

7.4 Methodological consideration and limitation

The innovative nature of this research (including defining a framework for perceived adaptive capacity, the subjective method of measuring a farmer's perceptions, and developing an index meant that there were limitations, both qualitative and quantitative. Utilising a sequential exploratory mixed method had the benefits of qualitative interviews followed by a quantitative survey. While the qualitative interviews were designed to inform the development of the survey, they were also used to explain the findings of the quantitative phase. This included farmers' perceptions of the seven dimensions as well as more detailed perceptions around human and social capitals. The qualitative phase was used to gain an understanding of the dairy farming context in terms of disturbances in the business environment, the five capitals for dairy farming, and the management practices to cope with disturbances. Without this phase, it would have been difficult to contextualise relevant questions for the survey. The mixed-method approach adopted for this study worked successfully as case farmers from the qualitative phase and responding farmers from the quantitative phase engaged well, providing a good dataset. However, the small sample size in the qualitative phase may be considered as a limiting item when the diversity of dairy farmers is not completely reflected in the four case farmers. While additional interviews may have added further detail to the study, it is important to note that four intensity cases[35] were considered to be adequate to meet the aims of the study. In addition, the financial and time limitations plus the availability of dairy farmers, who were eager to be interviewed, were also considered. Moreover, the quantitative phase was designed to cover the limitations of the qualitative phase where the survey provided data that represents a

[35] Intensity case is the case who is information-rich but not an extreme case.

diversity of dairy farmers in New Zealand that aligned with national statistics (DairyNZ, 2020b).

Another limitation is related to sample selection for the survey. Since a list of emails from an industry database was sent out and responding to the survey was a voluntary process, the researcher did not have control over the sample selection. However, the response rate was 31%, which is above the average response rate of 27% for research involving small businesses suggested by Bartholomew and Smith (2006). In addition, the measurement tool developed for perceived adaptive capacity later in the quantitative phase highlighted that each individual index is unique and cannot be generalised for the population. However, the dimension scores calculated from the PCA is sample dependant and will change with a different sample. In the current study sample size and sample selection were not considered problematic for the quantitative phase of the study.

While the survey data and the designed perceived adaptive capacity index provided some interesting insights into the farmers' perceptions, it is important to note that defining a new framework and the development of the index were both exploratory processes, where the researcher determined what data was appropriate for the story. However, the decisions were carefully considered and informed by the literature. In addition, findings from the qualitative phase informed the decision-making of the researcher. Moreover, limitations of the approach were addressed as far as possible to increase the reliability of the survey by using Cronbach's α and composite reliability test, the most common measures of internal consistency, reported in Appendix 7.

7.5 Areas for further studies

This study has provided a novel framework and some interesting findings around the dimensions of perceived adaptive capacity. However, a number of areas for future research have been identified.

This study has shown that classifying farmers as adaptive or less adaptive cannot be conclusive since each farmer has unique perceptions of the different dimensions in the context of dairy farming. In particular, the human and social capitals demonstrate more detail on individual differences between the farmers even if this results in the same index

score for farmers. In this regard, the attributes of human capital[36] have been explored in prior studies, through separately rather than together. Considering attributes together shows the relative importance of each attribute. Likewise, social capital aspects[37] are less explored in a disaggregated manner, this is also because of the difficulty in measuring social capital. While the importance of each social capital aspect can be determined by asking appropriate questions, the influence of each aspect, which is dependent on trust, is not easy to measure. Further studies with a focus on the role of trust in the importance of each aspect can lead to better measurement of social capital within the context of perceived adaptive capacity.

Questions elaborating on each dimension conducted in the survey can be used for further surveys over time, which helps with testing the reliability of questions on perceived adaptive capacity. Moreover, these questions can be utilised to group farmers based on their human and social capital responses but not for their overall perceived adaptive capacity. However, to identify and use a group of questions for each dimension, or attributes/aspect of a dimension, performing confirmatory analyses in large samples could be done in order to confirm or reject questions developed in this study. In addition, those questions related to the common disturbances for dairy farming in New Zealand can be changed according to the context and time for other groups of people.

Further research into the connection between a farmer's perceptions and actions would extend and enhance the findings of this research in assessing adaptive capacity, rather than measuring perceived adaptive capacity. Since adaptive capacity itself is not a measurable concept, the connection between a farmer's perceived adaptive capacity and his/her actions during a specific period of time can illuminate more on assessing their adaptive capacity.

7.6 Conclusion remarks

Beyond resilience, increasing adaptive capacity in a turbulent environment is an important goal for New Zealand dairy farmers. The turbulent environment including global market conditions and ongoing regulations within New Zealand and worldwide is not something within farmers' control, however, moves toward increased adaptive capacity within the

[36] The attributes of human capital are background, locus of control, self-efficacy, sense-making, strategic thinking, willingness to accept change, and open-mindedness

[37] Social capital aspects are value of trustworthy people, information source, community Involvement, bonding, bridging, and linking

industry should be taken more seriously. This study has shown that a major step toward understanding and increasing adaptive capacity starts from the farmer's perceptions of seven aforementioned dimensions, while considering ongoing and probable disturbances within each dimension. Further to this, the performance of farmers must be understood in parallel with their actions to adjust perceptions and actions to adapt to the current and future business environment. Therefore, this study makes an important contribution to the limited literature on the measurement of perceived adaptive capacity. While most studies attempting to measure adaptive capacity are focused on the performances as surrogates or some indicators, this research has emphasised the importance of the main decision-makers influencing the measurement of perceived adaptive capacity when they self-assess themselves. Moreover, perceived adaptive capacity is a pathway to assessing adaptive capacity by considering further assessment using objective methods.

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Appendices

Appendix 1: The five-production system definition described by DairyNZ

System	Definition
System 1	**All grass self-contained, all stock on the dairy platform** No feed is imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows are not grazed off the effective milking area.
System 2	**Feed imported, either supplement or grazing off, fed to dry cows** Approx 4 - 14% of total feed is imported. Large variation in % as in high rainfall areas and cold climates such as Southland, most of the cows are wintered off.
System 3	**Feed imported to extend lactation (typically autumn feed) and for dry cows** Approx 10-20% of total feed is imported. Westland - feed to extend lactation may be imported in spring rather than autumn.
System 4	**Feed imported and used at both ends of lactation and for dry cows** Approx 20 - 30% of total feed is imported onto the farm.
System 5	**Imported feed used all year, throughout lactation & for dry cows** Approx 25 - 40% (but can be up to 55%) of total feed is imported.
*Note: Farms feeding 1-2 kg of meal or grain per cow per day for most of the season will best fit in System 3.	

Appendix 2: Information Sheet and Participant Consent Form

Information Sheet

New Zealand dairy farmers' perceived adaptive capacity in the face of policy and economic volatility

Researcher(s) Introduction

My name is Elham Shokri, and I am a PhD student in the College of Sciences at Massey University. My research is under the supervision of Associate Prof. Peter Tozer, Dr. David Gray, Prof. Nicola Shadbolt from the Institute of Agriculture and Environment (IAE), and Dr. Sue Cassells from the School of Economics and Finance. This research is titled: "Sustainable production for New Zealand dairy farms: Dairy farms' adaptability to be resilient in the face of policy and economic volatility" and is supported by AgriOne, The Centre of Excellence in Farm Business Management. This work is part of a project, partially funded by DairyNZ, studying dairy farmer's resiliency. The study is looking for a measurement of dairy farmers' resiliency, which can be helpful in identifying what makes farmers stronger and resilient when facing different problems such as environmental challenges or regulations.

Participant Identification and Recruitment

I am seeking your input into this research because you are a dairy farmer. Therefore, you have a professional position in the industry and you have knowledge and experience that is likely to be of value to the research.

Project Procedures

In the first phase of this research project, four dairy farm owner-operators will be asked to provide information regarding their perceptions, beliefs, and reactions to different disturbances within the farm business environment. They will also be asked about their recent experiences of shocks or growing stress, and what they have done to cope with the problems raised. In addition, their reasons for choosing a particular management path and the skills necessary to follow this path will be investigated. Findings from this phase of the study will be used to design a new survey instrument to develop an index of dairy farmers' adaptive capacity, which is a key attribute of their resiliency.

I would appreciate if you would be willing to participate in this research project. If you are willing to participate, you will be first asked to complete a written questionnaire and answer questions on personal information such as education and training, goals, long-term plans and objectives, as well as information on your management strategies, and beliefs about disturbances within the farm business environment. The questionnaire is designed to take about 30-40 minutes of your time. You can choose not to answer a question should you prefer not to do so.

Following that, an interview will be organised to ask you about your experiences about shocks or growing stress for your farm business from markets or regulation/policies, the factors that influence the structure of your management strategies, and how you plan or manage any changes to your farm due to external shocks or stresses. With your agreement, the interview will be recorded to ensure accuracy in data collection and to assist the data analysis process. The recorded interviews will be summarized. The recordings and summary will be stored as digital files. Interviews will be undertaken at a time and location that is agreed to by you. Interviews will be a maximum of 90 minutes. You will be provided with a copy of the transcript or case report to ensure that you are satisfied with what is included in the transcripts. You will also have the opportunity to amend the transcript or case report if required.

Only researchers on the project will be privy to information such as questionnaire responses, and tapes, and interview transcripts. Unless consent is given, your name and identity will not be stated explicitly in the research. No data linked to an individual's identity will be published and only relatively generic information on you and your business will be provided to minimise the likelihood of your being identified.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question in the questionnaire;
- Decline to answer any particular question during the interview;
- Ask for the recording to be suspended at any time during the interview;
- Ask any questions about the study at any time during participation;

- Be given access to the interview recording should you want this, and a copy of the transcript or case report, with the right to modify the transcript or case report within two weeks of receiving this;
- Withdraw from the study up to two weeks after receiving the transcript or case report;
- Provide information with the expectation that your name will not be used in reporting;
- Be given access to a summary of the project findings when it is concluded.

Project Contacts

If you have any questions about the project, please contact the researcher and / or the supervisors:

Elham Shokri, E.shokri@massey.ac.nz ; phone 06 356 9099 ext. 85684;

Associate Professor Peter Tozer, P.tozer@massey.ac.nz

Dr. David Gray, D.I.Gray@massey.ac.nz

Professor Nicola Shadbolt, N.M.Shadbolt@massey.ac.nz

Dr. Sue Cassells, S.M.Cassells@massey.ac.nz

This project has been evaluated by peer review and judged to be low risk (Ethics Notification Number: 4000016229). Consequently, it has not been reviewed by one of Massey University's Human Ethics Committees. The researchers named above are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you wish to raise with someone other than the researchers, please contact Dr. Brian Finch, Director - Ethics, Massey University, telephone 06 356 9099 ext. 86015, email humanethics@massey.ac.nz.

Yours sincerely,

Elham Shokri

Participant Consent Form

New Zealand dairy farmers' perceived adaptive capacity in the face of policy and economic volatility

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to the interview being recorded;

Yes No

I agree to participate in this study under the conditions set out in the Information Sheet.

Yes No

Signature: …….. Date: …….

Full Name- printed: ……

Appendix 3: Online Survey form

Welcome to the survey. In this study, you will be asked to answer some questions about yourself, your farm business and your farm management ways. This study should take no more than 30 minutes. If you are ready to continue, click on the next page.

Please note that the information you provide in this survey will remain confidential. Your participation in this research project is really appreciated in advance.

Dairy farmers have entered an era of rapid and complex change through which they have to manage short-term shocks and long-term stresses from price fluctuations to environmental constraints. The resilience of a farming system helps to mitigate threats of uncertain disturbances like environmental constraints enacted in response to public concern over environmental degradation resulting from intensive farming. This study aims to define resilience in the context of New Zealand dairy farms and an understanding of how it can be measured as an emergent property. These 'measurements' can be useful to consider what a resilient farmer or farm business really looks like, and what are components of dairy farm resilience. This research study is titled "Dairy farmers' perceived adaptive capacity in the face of policy and economic volatility" and is being conducted by Elham Shokri. The supervisory team is Associate Prof. Peter Tozer, Dr. David Gray, Prof. Nicola Shadbolt, and Dr. Sue Cassells. If you have any questions or concerns about your participation in this study, you may contact the researcher at E.shokri@massey.ac.nz or the supervisory team at P.tozer@massey.ac.nz, D.I.Gray@massey.ac.nz, N.M.Shadbolt@massey.ac.nz, and S.M.Cassells@massey.ac.nz. A summary of the results will be available at "www.agrione.ac.nz" at the end of this research project.

If you are willing to participate, you will be asked to answer questions on personal information such as education and training, goals, long-term plans, and objectives, as well as information on your management strategies, and beliefs about disturbances within the farm business environment. The survey is designed to take about 30 minutes of your time.

Fam business

Please **fill in** the following information for **your dairy farm(s)**. If you own more than one dairy farm, please answer with reference to the three dairy farms that you are most actively involved with.

Dairy farm(s) geographical location

(North Island)

A	Northland	C	Bay of Plenty	E	Taranaki
B	Waikato	D	Hawkes Bay	F	Lower North Island

(South Island)

J	Nelson/Marlborough	L	North Canterbury	N	Otago
K	West Coast	M	South Canterbury	O	Southland

	Farm 1	Farm 2	Farm 3
Location (please choose your farm's region from the table next page, e.g. Northland=A)			
Type of dairy farm system (1-5)			
Milking platform area (effective ha)			
Non-milking area and/or runoff area (effective ha)			
Climate (Rainfall (mm))			
Pasture grown Per hectare/Per annum (kg DM/ha/yr)			
Total Kg MS produced for 2017/2018 season			
Cows milked at peak for 2017/2018 season			
Stocking rate (Cows peak milked per hectare)			
Building, dairy shed, vehicle, plant, and machinery approximate value ($)			
No. of employed staff (full-time equivalents)			
No. of family members involved in the farm (full-time equivalents)			

Please show any other distinctive features in relation to your farm(s):

	Farm 1	Farm 2	Farm 3
Irrigated (Yes/ No – ha)			
Organic farm (Yes/No, ha)			
Once a day milking (Yes/No, ha)			
Housed cows (Yes/No, Cow numbers)			
Winter milking (Yes/No, ha)			
Other (Please specify)			

The farmer

Please fill in the total number of years you have been involved in dairy farming: ☐

Please check your age range:

☐ **20-30 years** ☐ **31-40 years** ☐ **41-50 years** ☐ **51-60 years** ☐ **61-70 years** ☐ **71 years or more**

What is your gender?

Female ◯ Male ◯ I prefer not to say ◯

Please choose your highest level of formal education:

NCEA level 1/ school certificate	
University entrance/ bursary/ NCEA level 2 or 3	
Diploma graduate	
Degree graduate	
Postgraduate	
Other	

Please indicate the years of experience you have had in dairy farming (any role):

Role	None	Less than 5 years	6-10 years	11-15 years	16-20 years	21-25 years	More than 25 years
Farm worker							
Farm manager and/or contract milker and/or variable order sharemilker							
50-50 sharemilker							
Farm owner (operator and/or non-operator)							
Equity partner (operator and/or non-operator)							
Other (Please specify)							

What is your current role in the business?
Please tick the boxes. (If you own more than one dairy farm, please answer with reference to the three dairy farms that you are most actively involved with)

	Farm 1	Farm 2	Farm 3
50-50 sharemilker			
Farm owner (operator and/or non-operator)			
Equity partner (operator and/or non-operator)			
Other (Please specify)			

Which role is your main role in dairy farm management at the moment?

- 50-50 sharemilker
- Farm owner (operator and/or non-operator)
- Equity partner (operator and/or non-operator)

Please indicate the stage you are in dairy farm business

☐	Entry	☐	Consolidation (to maintain my farm as it is)	☐	Entry of next generation (before exit)
☐	Growth by expanding the farm size	☐	Improving farm performance (while maintaining current size)	☐	Exit

In terms of the long-term, within the season, and day-to-day decision-making on the farm, how much influence do you think you have?

	Very little	Little	Some	High	Very high
Long term					
Within the season					
Day-to-day					

Goal and management

Please tick to what extent you disagree or agree with the following statements.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I aim to minimise the use of agricultural chemicals on the farm to protect the environment.					
I know sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.					
I am willing to accept land-conserving costs besides my operation costs.					
It is important to have the best quality livestock.					
It is important to have the best quality pasture.					
I aim to make the largest possible profit.					
I aim to diversify my assets by having on-farm and off-farm investments.					
At the moment, I am happy to do the hard work to get more work-life balance in the future.					
Family situations influence my decisions about the farming operation.					
Family labour is an important part of my farm business.					
I want to make enough money to maintain a balanced lifestyle that incorporates interests outside of the farm.					
I want to operate this farm for the rest of my life and pass it on to my children.					
I want to sell the farm for a reasonable price when I get close to retirement.					
I try to build the infrastructure on my farm over time (gradually)					
When I make a decision, I turn to key people in my farm to get their point of views.					
Financial prosperity is a core to make ambition for expanding the business.					
I have tried to consider our business environmental footprint of our business and improve it to prevent future environmental costs.					

Farmer attributes

For each of the following statements, please tick the best point, which reflects your point of view.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
My family background in dairying has had an influence on my choice of a dairy farm business career.					
Dairy farming has been my career choice without any influence from the family.					
My farming knowledge is related to the location (region) that I am doing my job.					
I have gained extra qualification(s) to expand my farming knowledge.					
Non-farming experiences have changed my point of view about dairy farming.					
I am passionate about agriculture and dairy farming.					
I am confident that I can make "big" decisions correctly.					
When it comes to business, I like to play it safe.					
When there are a number of solutions to a problem, I find it difficult to make a choice.					
I am not good at making sense of ambiguous and uncertain situations.					
When confronted with a new situation, I review past experiences to assess the situation.					
I take every opportunity to expand my business.					
I review my farm business goals and plans on a regular basis (e.g. annually).					
I have regular contact with other members of the industry to acquire knowledge.					
I consider everyone in the dairy industry learns from each other.					
The success of my farm business is mostly determined by factors outside of my control.					
I have regular contact with other farmers where we discuss environmental restrictions.					

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Over the long term, I am able to manage almost all uncertainty that occurs.					
I value the knowledge of others from inside and outside the farm business.					
I intend to make time to implement changes required in my farm business.					
I am open to DairyNZ and am happy to be in discussion groups and the like.					
I am interested in university research looking to find good solutions regarding my farm business conditions.					
I try to keep myself informed.					
I am keen on reading newspapers or magazines with dairy news.					
I use the Internet regularly to keep myself informed.					
I try networking and talking to other farmers to get more information and practical management ideas/advice.					
I believe being in touch with vets regularly will help improve the animal health and production efficiency on my farm.					
I am quite involved in the community activities.					
I think I am still learning about dairying.					
My business reputation is very important and provides me with reasonable opportunities.					

Source of information

Please indicate the importance of involving other people when you want to make big decisions or implement changes in your farm business.

Source	Very low importance	Low importance	Important	High importance	Very high importance
Partner and family					
Friends					
Staff					
Feed suppliers					
Accountant					
Longstanding farm advisor					
Academic people					
Milk company staff (e.g. Fonterra, Open country, etc.)					
Banker					
Other farmers (e.g.					
DairyNZ staff					
Board of Directors					
Another consultant when I need specialist advice					
Regional council staff					
Fertiliser and seed representatives or AI technicians					
Veterinaries					
Other (Please specify)					

Regulation impact and planning

For each of the following statements, please tick the best point, which reflects your point of view.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I do not think of regulations as having a negative influence on my dairy business.					
I have thought about changing my land use if environmental issues prevent us from continuing to run a dairy operation.					
I can draw up a new business plan when it seems critical to current business in response to serious events like large price change.					
I have thought about exiting dairy industry if environmental issues prevent us from continuing.					
I prefer to be ahead of the regulations and then I know I am doing the best I can do.					
I have been thinking of farm business scale and considering expanding the business compatible with likely regulations.					
Any loss in milk production from future environmental requirements will prevent my business from achieving my long-term goals.					
To come along with health and safety compliance, I prefer to have highly skilled labour or the right people on my farm even though it means higher wages.					
I am aware that there will always be regulation changes in the future.					
I believe environmental organisations are consultative with dairy farmers.					
I think gaining consents will be tougher when in the future we wish to renew current consents.					
I know that stocking rates will come under more scrutiny in the future.					
For my farm business, fertiliser management is necessary.					
I reckon animal welfare is positively correlated with profitability.					
N leaching targets have had impact on our business.					

Perception of the farm business environment

Over the years the business environment evolves as changes occur in our global markets, legislation, and technology (to name a few). The results of these uncertainties could be beneficial, harmful or combination of both to your business. For each of the sources of uncertainty listed below, please indicate:

1. How do you perceive each uncertainty (opportunity/ threat)?
2. What you believe is the rate of change for your business in the coming five years (decreasing/increasing slowly/rapidly)
3. What you believe is the likelihood of this uncertainty happening for your business in the coming five years (rare to almost certain).

Sources of uncertainty	Opportunity	Threat	Opportunity & Threat	Level of uncertainty					The likelihood of happening				
				Decreasing rapidly	Decreasing slowly	Constant	Increasing slowly	Increasing rapidly	Rare	Unlikely	Possible	Likely	Almost certain
Climate variation													
Pasture/crop/animal health													
Interest rates													
Land values													
Availability of capital													
Milk prices													
Input prices and availability of inputs													
Availability of quality labour (self and family, employees, and contractors)													
Staff and/or personal injury													
Staff turnover													
Skills and knowledge of those associated with the business													
Technological changes													
Business relationships (with input providers)													
Dairy industry structure													

Sources of uncertainty	Opportunity	Threat	Opportunity & Threat	Level of uncertainty					The likelihood of happening				
				Decreasing rapidly	Decreasing slowly	Constant	Increasing slowly	Increasing rapidly	Rare	Unlikely	Possible	Likely	Almost certain
The global economic and political situation													
Global supply and demand for food													
Global competitors and competition													
Reputation and image of the dairy industry													
Government laws and policies (e.g. Environmental regulations)													
Local body laws and regulations													
Health and safety compliance													
Job Security													
Other uncertainties (please specify below)													

Management and response to changes

There are a number of recognised strategies for managing farm facing new situations; the following list includes some, but by no means all, of the strategies observed on dairy farms. For each of the following management strategies please indicate:

1. Do you use this strategy on your farm(s)? (Yes, No, NA: not Applicable)
2. If you use this strategy, indicate how important you believe this strategy is for managing risk on your dairy farm business (very low, very high).

Management methods	Use of this management			Importance				
	Yes	No	NA	Very Low	Low	Moderate	High	Very high
Having feed reserves on the farm								
Not producing to full capacity								
Geographic diversity through having properties in different area								
Using future markets								
Forward contracting								

Management methods	Use of this management			Importance				
	Yes	No	NA	Very Low	Low	Moderate	High	Very high
Gathering market information								
Monitoring programmes for pest and diseases control								
Routine spraying and drenching								
Spreading sales (reducing seasonality in milk production)								
Arranging overdraft reserves								
Maintaining financial reserves: having cash and easily converted financial assets								
Having infrastructure for soil management (barns, pads, drainage)								
Managing debt levels								
Keeping debt low or increasing equity								
Having off-farm investment								
Detailed financial planning								
Enterprise diversification								
Having personal and/or business insurance								
Implementing technological innovation								
Adjusting production methods/systems to comply with laws and policies								
Having a health & safety plan and keeping health and safety manuals up to date								
Assessing strengths, weakness, threats and opportunities of farm business								
Other (Please specify)								

Dairybase ID

Would you like allow the researcher to access your Dairybase data? Access to your Dairybase data will not affect the confidentiality of your responses and anonymity is guaranteed by the protocols in place.

Comments

Do you have any comments on likely upcoming regulations and their effects on your dairy business?

Thank you for participating.
This is the end of the survey and there is no submit button.
Please go to the next page and the survey will be recorded automatically.

Appendix 4: Examples of Principal Component Analysis output

Statements for natural capital:

Variable	Statement
N1	I aim to minimise the use of agricultural chemicals on the farm to protect the environment.
N2	I have tried to consider our business environmental footprint of our business and improve it to prevent future environmental costs.
N3	I know sacrificing farm profitability at some stage can prevent future environmental costs and can conserve water and other resources.
N4	I am willing to accept land-conserving costs beside my operation costs
N5	Improving environmental footprint has imposed some costs on our business
N6	I aim to diversify my assets by having on-farm and off-farm investments

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.594
Bartlett's Test of Sphericity	Approx. Chi-Square	46.012
	df	15
	Sig.	.000

These two show the sufficiency of sample for this analysis.

Communalities

	Initial	Extraction
N1	1.000	.562
N2	1.000	.619
N3	1.000	.605
N4	1.000	.509
N5	1.000	.719
N6	1.000	.433

Extraction Method: Principal Component Analysis.

These are loadings indicate the statements that are related to Principal Component.

Component Matrix

	Component 1
N1	.462
N2	.123
N3	.768
N4	.075
N5	.843
N6	.559

These are the coefficients used for calculating the score for the first principal component.

Bonding is a sub-criteria for social capital (with 3 variables) and the PCA score for this sub-criteria comes out of PCA output:

Variable	Bonding
S13	Partner and family
S14	Friends
S15	Other farmers (e.g. neighbours)
S22	Staff

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.557
Bartlett's Test of Sphericity	Approx. Chi-Square	16.956
	df	6
	Sig.	.009

Communalities

	Initial	Extraction
S13	1.000	.914
S14	1.000	.573
S15	1.000	.423
S22	1.000	.699

Extraction Method: Principal Component Analysis.

Component Score Coefficient Matrix

	Component 1
S13	.122
S14	.462
S15	.383
S22	.501

The total Social capital PCA score is a bottom-up process that includes all six sub-criteria PCA scores: Social capital sub-criteria are1) value of trustworthy people, 2) information source, 3) community Involvement, 4) bonding, 5) bridging, and 6) linking.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.740
Bartlett's Test of Sphericity	Approx. Chi-Square	76.592
	df	15
	Sig.	.000

Communalities

	Initial	Extraction
Svalue	1.000	.509
Sinfo	1.000	.720
Sinvolve	1.000	.544
Sbond	1.000	.477
Sbridge	1.000	.717
Slink	1.000	.655

Extraction Method: Principal Component Analysis.

Component Score Coefficient Matrix

	Component 1
Svalue	.238
Sinfo	.154
Sinvolve	.275
Sbond	.236
Sbridge	.297
Slink	.300

Appendix 5: Relative importance of attributes within human capital dimension

ID	Background	Locus of control	Self-efficacy	Sense-making	Strategic thinking	Willingness to accept change	Open-mindedness
1	8%	8%	8%	8%	14%	22%	34%
2	4%	8%	8%	13%	13%	33%	22%
3	5%	5%	20%	12%	8%	20%	31%
4	4%	6%	11%	11%	11%	28%	28%
5	10%	10%	18%	6%	10%	30%	18%
6	11%	11%	11%	6%	11%	20%	32%
7	4%	22%	13%	8%	8%	22%	22%
8	5%	12%	19%	13%	8%	22%	22%
9	11%	10%	11%	6%	11%	20%	32%
10	3%	7%	18%	11%	5%	28%	28%
11	5%	14%	8%	14%	8%	25%	25%
12	5%	15%	15%	8%	15%	15%	27%
13	7%	7%	7%	13%	13%	21%	33%
14	19%	11%	4%	11%	7%	30%	19%
15	3%	5%	19%	11%	11%	31%	19%
16	6%	15%	4%	15%	9%	25%	25%
17	7%	13%	13%	7%	7%	21%	33%
18	5%	33%	5%	5%	9%	21%	21%
19	6%	7%	17%	7%	7%	28%	28%
20	5%	18%	10%	10%	10%	18%	30%
21	10%	10%	6%	18%	10%	18%	30%
22	5%	15%	5%	15%	9%	25%	25%
23	10%	19%	19%	10%	6%	19%	19%
24	5%	12%	21%	7%	12%	21%	21%
25	5%	21%	7%	12%	12%	21%	21%
26	7%	22%	12%	4%	12%	22%	22%
27	3%	5%	19%	7%	15%	26%	26%
28	7%	12%	21%	12%	7%	21%	21%
29	3%	10%	6%	14%	6%	31%	31%
30	5%	17%	5%	7%	11%	28%	28%
31	3%	18%	7%	7%	7%	28%	28%
32	6%	6%	10%	10%	16%	27%	27%
33	5%	8%	14%	14%	8%	25%	25%
34	13%	13%	5%	7%	7%	21%	33%
35	8%	5%	8%	14%	14%	25%	25%
36	5%	9%	24%	9%	5%	24%	24%
37	11%	11%	11%	6%	4%	28%	28%
38	7%	13%	13%	13%	7%	24%	24%

ID	Background	Locus of control	Self-efficacy	Sense-making	Strategic thinking	Willingness to accept change	Open-mindedness
39	4%	15%	25%	9%	6%	25%	15%
40	14%	8%	14%	8%	8%	25%	25%
41	5%	12%	7%	12%	21%	21%	21%
42	5%	12%	21%	12%	7%	21%	21%
43	15%	9%	9%	6%	4%	34%	23%
44	7%	13%	7%	13%	12%	18%	32%
45	8%	8%	14%	8%	14%	25%	25%
46	8%	4%	26%	8%	13%	4%	37%
47	3%	16%	10%	19%	13%	19%	19%
48	4%	4%	16%	7%	16%	26%	26%
49	4%	10%	19%	10%	19%	19%	19%
50	4%	16%	9%	9%	9%	26%	26%
51	6%	10%	4%	10%	6%	32%	32%
52	4%	13%	23%	8%	8%	23%	23%
53	5%	8%	8%	8%	1%	30%	30%
54	5%	14%	8%	8%	8%	23%	34%
55	6%	6%	17%	7%	7%	27%	30%
56	7%	7%	22%	7%	13%	22%	22%
57	7%	13%	13%	13%	7%	24%	24%
58	11%	3%	20%	20%	7%	20%	20%
59	4%	12%	19%	7%	7%	19%	31%
60	9%	5%	16%	9%	9%	26%	26%
61	5%	9%	5%	10%	10%	37%	24%
62	4%	11%	19%	7%	11%	19%	30%
63	8%	14%	14%	8%	25%	8%	25%
64	4%	13%	8%	13%	24%	24%	13%
65	5%	5%	15%	15%	9%	25%	25%
Min	3%	3%	4%	4%	1%	4%	13%
Max	19%	33%	26%	20%	25%	37%	37%
Mean	6%	11%	13%	10%	10%	24%	26%
STDEV	0.03	0.05	0.06	0.03	0.04	0.05	0.05

Appendix 6: Relative importance of aspects within social capital dimension

ID	Value of trustworthy people	Information source	Community Involvement	Bonding	Bridging	Linking
1	25%	38%	16%	10%	6%	6%
2	22%	22%	22%	5%	8%	21%
3	26%	14%	26%	5%	14%	14%
4	25%	11%	25%	12%	13%	13%
5	26%	14%	26%	14%	8%	14%
6	21%	35%	21%	8%	8%	8%
7	23%	23%	23%	7%	12%	12%
8	22%	35%	12%	12%	12%	7%
9	25%	25%	25%	9%	6%	9%
10	30%	11%	30%	11%	6%	11%
11	24%	24%	24%	8%	8%	13%
12	16%	20%	33%	7%	12%	13%
13	21%	21%	21%	5%	11%	21%
14	21%	21%	21%	7%	7%	21%
15	14%	33%	33%	9%	6%	6%
16	19%	33%	19%	11%	6%	11%
17	19%	30%	30%	5%	8%	8%
18	19%	10%	33%	9%	13%	17%
19	17%	31%	17%	9%	9%	17%
20	36%	23%	23%	6%	6%	6%
21	27%	27%	27%	7%	5%	7%
22	23%	23%	23%	7%	12%	12%
23	26%	26%	14%	8%	14%	14%
24	19%	30%	30%	7%	7%	7%
25	19%	31%	31%	5%	9%	5%
26	18%	29%	29%	6%	6%	11%
27	32%	32%	14%	5%	8%	8%
28	16%	28%	28%	9%	9%	9%
29	38%	14%	14%	7%	14%	14%
30	38%	16%	25%	6%	10%	6%
31	26%	39%	10%	10%	6%	10%
32	31%	17%	17%	17%	9%	9%
33	25%	38%	16%	10%	6%	6%
34	21%	35%	21%	8%	8%	8%
35	18%	29%	29%	11%	6%	6%
36	24%	37%	15%	9%	9%	5%
37	31%	18%	18%	6%	10%	18%
38	14%	26%	26%	8%	14%	14%
39	24%	24%	24%	14%	5%	8%

ID	Value of trustworthy people	Information source	Community Involvement	Bonding	Bridging	Linking
40	17%	41%	17%	10%	6%	10%
41	24%	24%	24%	8%	14%	5%
42	14%	26%	26%	14%	14%	8%
43	19%	33%	19%	6%	11%	11%
44	22%	22%	35%	9%	6%	6%
45	15%	27%	27%	15%	8%	8%
46	14%	33%	33%	6%	6%	9%
47	20%	33%	20%	11%	11%	5%
48	17%	17%	31%	9%	9%	17%
49	28%	28%	28%	4%	4%	9%
50	19%	33%	16%	11%	5%	16%
51	29%	18%	29%	5%	11%	7%
52	22%	35%	12%	7%	12%	12%
53	11%	30%	30%	11%	6%	11%
54	24%	37%	15%	8%	8%	8%
55	23%	36%	13%	7%	7%	13%
56	15%	27%	27%	8%	15%	8%
57	17%	29%	29%	6%	10%	10%
58	24%	24%	24%	14%	8%	5%
59	23%	36%	14%	5%	14%	8%
60	32%	32%	14%	8%	5%	8%
61	17%	29%	29%	6%	10%	10%
62	14%	23%	36%	14%	8%	5%
63	30%	30%	18%	5%	5%	12%
64	27%	27%	15%	6%	15%	9%
65	20%	34%	20%	7%	7%	12%
Min	11%	10%	10%	4%	4%	5%
Max	38%	41%	36%	17%	15%	21%
Mean	22%	27%	23%	8%	9%	10%
STDEV	0.06	0.08	0.07	0.03	0.03	0.04

Appendix 7: Reliability tests for each group of questions in the survey

Dimensions	Cronbach's α *	Composite reliability test **
Uncertainties	**0.88**	**0.52**
Management practices	**0.90**	**0.50**
Natural capital	**0.50**	**0.76**
Physical capital	**0.60**	**0.79**
Financial capital	**0.50**	**0.73**
Human capital	**0.64**	**0.68**
background	0.60	0.74
Locus of Control	0.54	0.70
Self-efficacy	0.51	0.82
Sense-making	0.50	0.78
Strategic thinking	0.76	0.74
Willingness to accept change	0.50	0.80
Open-mindedness	0.69	0.80
Social capital	**0.85**	**0.88**
Value of trustworthy people	0.50	0.70
Source of information	0.50	0.82
Involvement in community	0.52	0.68
Bonding	0.50	0.76
Bridging	0.82	0.72
Linking	0.51	0.78

*The Cronbach's α coefficient of reliability ranges from 0 to 1 in providing this overall assessment of a measure's reliability. If all of the scale items are entirely independent of one another (i.e., are not correlated or share no covariance), then α = 0; and, if all of the items have high covariances, then α will approach 1 as the number of items in the scale approaches infinity. In other words, the higher the α coefficient, the more the items have shared covariance and probably measure the same underlying concept (Gliem & Gliem, 2003). It is recommended a minimum α coefficient between 0.65 and 0.8 (or higher in many cases). However, for a group of questions related to their nature, it can be accepted if less than 0.65 while less than 0.50 is introduced as unacceptable (George & Mallery, 2019).

**Composite reliability (sometimes called construct reliability) is a measure of internal consistency in scale items, much like Cronbach's α (Netemeyer et al., 2003). It can be thought of as being equal to the total amount of true score variance relative to the total scale score variance (Brunner & SÜβ, 2005).