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Exploratory Research into the Resilience of Farming Systems during Periods of Hardship

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Summary

This paper investigates the management strategies and responses used by New Zealand sheep and beef farmers to ensure resilience during periods of hardship. Using two, farm level surveys conducted in 1986 and 2010, some aspects of resilient farming systems were identified. Despite apparent hardship current farmers seemed more willing to take risks, with many more borrowing to invest in on farm developments than those in 1986. The main similarity between time periods was the greatest response to economic changes being the adoption of a low input policy. This result was quite significant, as conventional farmers are generally believed to resort to other strategies or responses.

Keywords: Resilience, New Zealand, indicators, sustainable agriculture, strategies

Introduction

The economic, social and environmental climate is changing with human and biophysical activities arguably having an ever-greater effect on the earth's systems and the human societies within them. This unpredictable change is said to have an impact on systems at all spatial and temporal scales with human systems, such as the food production system, feeling the effects at global, regional and local scales. In order to remain and cope with the pressures, disturbances and shocks created by this ever-changing environment, economic systems must become more resilient. Resilience denotes the ability of a system to absorb and manage changes and perturbations without changing into another qualitative state with other defining characteristics (Folke, 2006). Food production and agricultural systems are affected by these unpredictable global

changes with New Zealand's primary sector being no exception. How farmers in New Zealand react and strategise will depict their level of resilience and thus the continued survival of their enterprise.

The idea of resilience emerged from the field of ecology in the early 1970's with Holling first providing a definition in 1973. After two decades as a term almost solely used in ecological disciplines it began to emerge in literature from social and economic disciplines in the early 90's frequently being redescribed as its application expanded (Folke, 2006), at this point it's development in an operational context was limited. By the late 90's there had been increasing multi-disciplinary use of the resilience concept with it seen as significant in achieving strong sustainability (Perrings, 1998) and as an approach to understanding social-ecological system dynamics. Despite a steady flow of publications since, the concept seems to have had little application to food and agricultural systems.

This paper contributes to this literature by looking at farm level agricultural systems and the ways in which farmers manage their business to ensure it remains resilient and sustains in the face of environmental, financial, political and social pressures. It examines the ways in which farmers, in particular New Zealand farmers, adapt to and cope with external and internal changes. Through comparing results of farm level surveys collected by Fairweather in 1986 and the Agricultural Research Group on Sustainability (ARGOS) in 2010, some of their main strategies and responses are identified and ways in which these help maintain the function and identity, and thus the resilience, of the farming systems. These two periods were of significance as they were both times of hardship within the New Zealand agricultural industry. The 1986 sample was collected after the removal of agricultural subsidies and import tariffs in 1985, additionally; around the same time banks changed their lending requirements, making it more difficult to borrow. On the other hand the 2010 sample was taken in the period following the 2008 global recession.

A selection of different questions were included in the recent 2010 survey looking more specifically at the current farming environment, management practices, and farm financing. Further to this survey, ARGOS farm financial records collected annually since 2002 were also analysed.

Literature Review

Characteristics of Resilience

In classical mythology, the symbol of resilience was the reed because of its ability to both sway in the breeze and to with withstand the fierce storms that would uproot mighty trees. Its origins are derived from the Latin word resilire which means to rebound, recoil or return to the original form. In English, resilience was first used in the

17th Century to refer to the ability of certain timbers to withstand immense loads without breaking (Prosser & Peters, 2010).

Today, resilience tends to be used to either mean a capacity to 'bounce back' or a tendency to resist change. In everyday speech a resilient person is one who can navigate the ups and downs of life, emerging unscathed. However, over the years, resilience has also been adopted and used in a range of more specific ways.

The resilience perspective emerged from ecology in the 1960's and early 1970's following concerns about loss of environmental ecology. It was developed through studies on the persistence of populations or communities at the ecosystem level. Holling (1973) first defined resilience as a "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973, p. 14). Due to the multi-disciplinary applications of resilience there have been numerous attempts at defining the concept, with it transforming considerably since its introduction in 1973. Since this original scientific definition authors have put forward many others from various disciplines.

Perhaps the most significant in this context are the operational, ecological-economical and sustainability-related definitions. The operational definition is for application of the resilience concept to empirical cases and states that it is critical to specify resilience "*of* what *to* what" (Carpenter, Walker, Anderies, & Abel, 2001). This represents a step to make resilience tangible. Cumming et al suggest further operational steps focusing on the concept of identity, defining resilience as the system's ability to maintain its identity in the face of internal change and external shocks and disturbances (Cumming et al., 2005).

Economy-environment systems have also been analysed using the concept of resilience. Resilience is equivalent to the transition probability between states as a function of the consumption and production activities of decision makers (Brock, 2002). While Perrings (2006), sees the ecological system properties of adaptive capacity and robustness as relating to resilience in economic systems. Defining resilience as the "the ability of the system to withstand either market or environmental shocks without losing the capacity to allocate resources efficiently or to deliver essential services" (Perrings, 2006, p. 418). This looks at the ability of a system to accommodate perturbations without losing functionality within the market and supporting institutions or the functionality of production systems. The difficulty is how to determine what changes to species or resource diversity will change the dynamics and economic value of a system. This involves understanding the importance of a mixed portfolio of biotic and abiotic environmental assets in the management of sustainable, resource-based economic development, which, in many systems, is not always clear (Perrings, 2006).

Sustainability perspectives have also suggested incorporation of resilience into guidelines for strong sustainability (Ott, 2003). This looks at the long-term maintenance of natural capital in order to provide ecosystem services that provide instrumental as

well as personal well-being values for society. Natural along with other types of capital are discussed in more detail in later sections of this paper.

Early studies of resilience looked at equilibrium states and the desire for systems to maintain positions close to their believed optimum, since system resilience is often seen more as its capacity to remain within certain boundaries during disturbance and shocks. Hence there are two main variants in the concept of resilience. One focussed on the time taken for a disturbed system to return to some initial state or equilibrium. The other concerned with the magnitude of disturbance that can be absorbed before the system flips from one state to another. Aspects of the stability of system equilibria are concentrated on within both, offering alternative measures of the capacity of a system to retain productivity following disturbance (Perrings, 1998).

Is assessing resilience both specified and general resilience need to be included. Specified resilience is that of a particular stock, flow or valued product to an identified shock. General resilience on the other hand is where neither system attribute nor kind of external disturbance is identified. Both aspects concern the system's ability to absorb shocks and not cross thresholds that will lead the system to change state or collapse (B. H. Walker & Pearson, 2007).

Within the operational definitions outlined above Carpenter et al. (2001) speak of the resilience "of what to what". Firstly, "of what" looks at the system state being considered, secondly the "to what" part of this analysis explains to what a certain regime of a system should be resilient. This means to specify the disturbance regime, for example, the kind of disturbances, their frequency, and intensity. These may include both human and natural disturbances as well as possible cumulative effects that may arise (Carpenter et al., 2001).

The resilience approach emphasises non-linear dynamics, thresholds, uncertainty, and surprise, how periods of gradual change interact with periods of rapid change and how such dynamics interact across temporal and spatial scales (Folke, 2006). Change is inevitable in resilience theory and the ability to manage change is the key to managing social-ecological systems. Different hierarchical levels operate at different spatial and temporal scales and within systemic structures interact between these scales. Systems at high levels such as climate change and the nation state develop and undergo change slowly. On the other hand systems at lower levels such as local communities and watersheds undertake more rapid change. All variables are capable of effecting variables at other scales (B. Walker et al., 2006).

An issue with many of the current resilience definitions is they provide limited interpretations or may lead to distortions in empirical application. This problem is due to the lack of any distinguished measurable variables. Such present variables are necessary in fieldwork in order to measure and gauge system resilience in the future. Defining these initial current resilience measurements well essentially leads to well rounded conclusions (Cumming et al., 2005). As is defined in the operational definition above, a systems ability to maintain identity through change, shocks and disturbance is seen as easier to identify and analyse. A systems identity is largely dependent on (1) the

components making up the system; (2) the relationships between components; and (3) the ability of components and relationships to maintain themselves continuously both spatially and temporally (Wiggins, 1990; Cumming & Collier, 2005, as cited in Cumming et al, 2005). Identity maintenance also incorporates (4) innovation and self-organisation. Resilient systems will naturally be capable of adjusting to a variety of exogenous conditions; however resilience can also be affected (positively or negatively) by innovation. These four identity characteristics are described below.

System components basically incorporate the pieces of the system. They include such things as various kinds of human actors; ecosystem or habitat types; resources, goods or materials; and chemical or physical variables. Inclusion of these and their boundaries are dependent on the focus area. Relationships describe the ways these components interact and fit together. Common relationships of interest include nutrient cycles, food webs and trophic interactions, economic and ecological competition, land tenure systems and interactions between human actors (Daily et al., 1997; Ostrom, 1990; Harris De Renzio, 1997, as cited in Cumming et al, 2005). Specific system components and relationships will change over time but it's essential identity attributes must be maintained to be considered resilient. A systems ability to maintain as a cohesive entity also requires spatio-temporal continuity. This is facilitated by system memory which may take the form of seed banks, elderly people, customs and taboos, laws, social and biological legacies that remain after disturbances or formal archives and libraries that become storage areas of knowledge and also of identity (Cumming et al., 2005).

As the resilience concept emerged from ecology, many of its systemic ideas link back to ecosystems and their functions. This is seen in the varied viewpoints and ongoing discussion on system diversity and its relation to system resilience. One belief is that more complex systems are less resilient because of their high degree of 'connectedness', the level of independence of individual processes. Loss of one species in highly 'connected' systems may imply loss of others (May, 1972). Others argue that while resilience is not necessarily a task of increasing species diversity, ecosystem resilience does depend on the range of functional species capable of supporting the critical compositional processes of those systems under different environmental conditions. These functional species groups are known as 'drivers', which consist of the keystone species that control the future of an ecosystem, while the 'passengers' live in but do not significantly alter this ecosystem (Gunderson, 2000). However, as conditions change, endogenously and exogenously, species shift roles. Within a systems' structure removing drivers can have a great impact while loss of passengers has little effect. Ecological resilience resides in the diversity of drivers but also in the number of passengers who are potential drivers. Passengers under one set of environmental conditions may have a key role to play under other environmental conditions. Such diversity provides robustness to ecosystem functions and resilience to changes and disturbance within the system (Gunderson, 2000). Nurturing this diversity is seen by Berkes (2007) as one of the key factors in building resilience.

Four critical clusters of factors are considered important in building resilience, factors that interact across temporal and spatial scales and seem to be required for dealing with the dynamics of social-ecological systems. These factors are (1) learning to live with

change and uncertainty, (2) nurturing diversity for reorganisation and renewal, (3) combining different types of knowledge for learning, and (4) creating opportunity for self organisation toward social-ecological sustainability (Folke, Colding, & Berkes, 2003). Below Berkes (2007) interprets and discusses these resilience building strategies.

Learning to live with uncertainty requires building a memory of past events, abandoning the notion of stability, increasing the capability of learning from crisis and having the tools and codes of conduct to fall back on when an unexpected event happens (Hewitt, 2004 as cited in Berkes, 2007). Major changes like natural disasters can be very damaging and some degree of renewal is necessary for the system. A resilient system therefore retains the necessary elements for organisation and renewal (Folke, Hahn, Olsson, & Norberg, 2005). Social memory (as in the rules of conduct in the event of a hurricane) and ecological memory (as in the seeds that survive a forest fire) are part of the elements of system renewal. Each system renewal cycle brings with it windows of opportunity for change (Berkes, 2007).

Diversity provides the seeds for new opportunities in the renewal cycle. It increases the options for coping with shocks and stresses, making the system less vulnerable. Diversification is the universal strategy aimed at risk reduction, through spreading them out, and increasing options in the face of hazards (Turner et al., 2003). Ecological, economic and population diversity can be nurtured to increase management options. Genetic, species, and landscape levels of biodiversity are often important for resource based rural communities with livelihoods options based on access to such resources in space and time (Berkes, 2007). Many traditional management systems have specialised practices and knowledge to use and maintain a diversity of resources that provide livelihood portfolios rather than the simplified, efficiency driven ecosystems created by agro-industrial monocultures (Berkes and Folke, 1998, as cited in Berkes, 2007). Diversity feeds more economic opportunities with rural livelihoods and well-being being strongly dependent on the diversity and health of ecosystems and the services they provide such as food, fuel, water purification and disease regulation. Ullsten *et al* (2004) identify local economic diversification as an important policy objective in the building of resilience (Ullsten, Gustave Speth, & Chapin, 2009). A diversity of constituencies in the policy arena contribute a broad range of views and considerations with the potential of bringing new thinking and expanding the role of information, education and dialogue (Turner et al., 2003).

Combining traditional, local knowledge with more globalised, scientific knowledge can develop collaboration and communication. Complex systems problems, such as environmental change, cannot be analysed at one level alone. Complex systems phenomena occur on multiple scales with cross-scale feedbacks requiring multilevel analysis. Community-based monitoring and indigenous observations complement global science by filling the gaps and providing insights regarding local impacts and adaptations (Berkes, 2002). Bringing together parties with different relative strengths in terms of knowledge and backgrounds helps increase the capacity to learn.

The resilience of a system is closely related to its capacity for self organisation because nature's cycles involve renewal and reorganisation (Holling, 2001). Berkes (2007)

outlines several aspects of self-organisation that are significant for reducing vulnerability to hazards. These aspects are (1) strengthening community based management (Berkes and Folke, 1998, as cited in Berkes, 2007), (2) Building cross-scale management capabilities (Folke et al., 2005), (3) strengthening institutional memory (Folke et al., 2005), and (4) nurturing learning organisations and adaptive co-management (Olsson et al, 2004, as cited in Berkes, 2007).

Darnhofer (2010) interprets and discusses these resilience-building strategies with regard to agriculture later in this text.

Resilience in Economic Systems

Economic systems are non-linear and adaptive, exhibiting complex and far from equilibrium dynamics, much the same as ecological systems. In these systems, small or medium sized disturbances may be beneficial for the growth of productivity. It is these disturbances that in the long run, through the creative entrepreneurs identifying gaps, create economic growth and an ability to survive major changes such as economic depressions. This is seen in companies within stable, sheltered environments with little competition and their relative lack of flexibility. Companies that are always fighting for survival develop resilience much more fully, partly due to the necessity to increase productivity (Levin et al., 1998).

In economic systems, resilience depends on effective feedback mechanisms; the coupling of stimulus and response; and a diversity of resources (Levin et al., 1998). Growth rates tend to stabilise with increasing firm size, leading to firm persistence and opportunity for long term growth. This positive feedback loop allows large firms to capture more resources, thus large firms in an industry rarely relinquish their dominance. Smaller firms are generally not capable of competing with larger firms, so exploit niches better suited to their capabilities. Therefore the most resilient industries will be those with functions spread across a range of firm size (Garmestani, Allen, Mittelstaedt, Stow, & Ward, 2006).

Resilience of Agricultural Systems

Farm and agriculture related resilience literature is reasonably limited. Most significant are a few stand alone shock specific studies (e.g. Kaine & Tozer, 2005; Young et al., 2006) focusing on the impacts of drought. Darnhofer *et al* (2010) on the other hand look at general farm resilience while Darnhofer (2010) looks more at building farm resilience within family farms in Austria.

Farmers are facing an increasingly turbulent environment with shocks and stresses from localised to global sources. These include: food scares (e.g. BSE, swine influenza),

increasing frequency of extreme climatic events (floods, droughts), new pests and weeds linked to climate change, increasing environmental and animal welfare regulation, ageing of the population, change in consumer preferences, multinational competition, volatility of commodity prices and new technological developments (e.g. genetically modified crops). In considering the tight interconnection of these unforeseen developments as well as their spatial linkages due to globalisation, rather than devoting attention to development of sophisticated forecasting and risk assessment techniques, resilience thinking focuses more on enabling a system to cope with unexpected change and disturbance (Darnhofer, 2010). Thus, management strategies that both allow farms to persist and maintain through shocks and those that allow them to adapt and adopt new states when they are needed or seem opportune are vital (Darnhofer, Fairweather, & Moller, 2010).

Within the resilience management of a farm its various subsystems maintain a level of autonomy in that they undergo a long-term cycle, however there are interactions with other subsystems at different spatial scales and within other domains that have an influence on the farm's systems (Darnhofer et al., 2010). With spatial scales ranging from plot and farm level to global level and the different dynamics of ecological, social and economic domains it is clear why managing farm resilience can be so complex.

A further aspect of this complexity contributing to the unpredictability of these dynamics is the fact that subsystems evolve at different speeds. Aspects such as disease and consumer preferences often change rapidly while aspects such as global warming change more gradually. Such drivers of the food system often have differing spatial and temporal scales along with domain variations (Darnhofer et al., 2010).

In a more system specific study, Kaine and Tozer (2005) designed model simulations to explore the economic and biological stability and resilience of pasture based steer fattening in New South Wales, Australia. These looked at the interrelations between stocking rates or rotations and biological stability and the impact of introducing shocks in the form of droughts. Their results showed that at low stocking rates pasture had good biological stability (biomass, species composition, growth rates) but lead to low cash flow. Increasing stocking rates reduced this stability until pasture system collapse occurred at very high rates. Predictably, cash flow responded positively to stock increases. As for rotation period, increasing days per paddock caused detrimental changes to pasture composition. The enterprise was thus less resilient to drought, becoming economically and biologically unsustainable in moderate to severe droughts (Kaine & Tozer, 2005). This study clarifies the optimal balance between efficiency and resilience in achieving sustainability in an applied setting.

Young *et al* (2006) describe resilience to the external disturbance of drought in agro-pastoral society through observing different aspects and timeframes. The size of the drought's impact is quantified as the amount of water 'missing' at any one time and place, and the disturbance this lack causes. Drought duration is also another significant variable in that resilience is tested more with each consecutive year. Various observations have confirmed that tapping into reserves and other resources enables survival in the first year of severe drought. These reserves are generally insufficient by

the second year and stock must be reduced, by the third year enterprise survival is threatened, as necessary stock reductions leave no resources for revenue in future years. In addition to this temporal scale, spatial scale determines how many people (or animals, crops, etc.) are involved in the disaster and indirectly the duration of damage recovery (Young et al., 2006).

Darnhofer (2010) applied the four clusters of factors discussed by Berkes (2007) as being important for strategies building resilience (outlined above), at the farm level in Austria. Adaption and change are conducted in the enterprises on-farm, and the wider on- and off-farm activities family members are involved in. Through resorting, adjusting and reconfiguring farm activities, the farm can adapt and take advantage of new opportunities. Resilience thus focuses on the farm system, on preserving its functions, not at preserving individual production activities on the farm (Darnhofer, 2010).

Learning to live with change and uncertainty was the first factor Berkes (2007) identified for resilience building. Darnhofer (2010) relates this to the perception and worldview of the farming family and to ensuring a degree of flexibility and adaptivity. In this study farmers mainly identified 'stress' type changes such as changes in social norms and expectations, the rise of environmental regulations and aging rural populations. In addition, two shocks were also discussed, one financial, the opening of the boarders to Eastern European countries, the other environmental, the 2004 flood. Through awareness of larger societal framework changes farmers keep flexible by avoiding committing a large share of resources to one activity that might become unviable as the economic or policy environment changed. Operationally farmers kept debt levels low relative to farm assets, large investments requiring bank financing were generally avoided due to the possibility of significant change, especially in agricultural policy. The majority of changes implemented were smaller scale and worked on existing knowledge and strengths to adjust direction or diversify (Darnhofer, 2010).

Darnhofer (2010) identifies how nurturing diversity at farm level incorporates many different variables contributing to diversity in economic opportunities, resources, information sources, communication partners, relationship types and of course biological diversity. Approaches to diversity at the farm scale often involved diversifying the enterprise by including niche crops alongside commodity crops. Many farm families had at least one family member in off-farm employment providing an income supplement and increased social connections. Many farmers showed an entrepreneurial spirit, actively experimenting with new activities, these sometimes leading to new markets (Darnhofer, 2010). Darnhofer's findings are supported by Di Falco and Chavas (2008) who found that within agriculture, a more diverse agro-ecosystem will have a broader range of traits and have a greater likelihood of performing under different environmental conditions (Di Falco & Chavas, 2008).

At the farm level combining different knowledge and learning types incorporates information utilised in making decisions, network involvement and farmers' ability to build on past experience and traditions. Farmers are constantly integrating information from the scientific and practical 'real-life' world. They routinely compare their own

knowledge gained from observations and experimentation with scientific information, appreciating their complementarity (Darnhofer, 2010).

In this study farmers used a range of strategies to strengthen their farm level self organisation and autonomy. A major theme was the aim of increasing on farm resource self sufficiency while at a community level they viewed the ability to cooperate and networks as a key for survival, especially among smaller scale operations. In contrast to increased operational autonomy building cross-scale linkages through engagement with various institutions, such as farmers associations or government agencies, was also considered important. These connections allow information flow from central structures, such as that about agricultural policy changes.

Here the question still remains, 'what is a resilient farm?' How can we gauge a resilient farm? Can we use changes in capital based sustainability indicators to indicate how resilient a farm is? In this we can look at human, natural, social, cultural and human made capital.

With respect to sustainability, indicators are defined as "Quantitative measures of progress toward or away from a stated goal" (Parris & Kates, 2003, p. 573) or simply metrics that are used to describe the "status, trend, or performance of underlying complex systems" (McCool & Stankey, 2004, p. 295). Indicators have been designed and used to 'indicate' multiple aspects of sustainability and serve many purposes including the determination of baseline conditions, prediction of future trends, and as monitoring and warning systems. Also indicators can be used for making comparisons (across time and space or with targets), performance review and improving scientific understandings (Milman & Short, 2008). With these definitions considered it is feasible that indicators could be used to quantify resilience.

Human capital includes individual's embodied knowledge, skills, competencies and attributes and their ability to create personal, social and economic well-being. It is developed through lifelong experience combined with formal education (Saunders, Kaye-Blake, & Campbell, 2010). Workers who contribute to the agricultural sector, for example, include field workers (farmers, growers and their employees) and external contributors such as agricultural researchers and government officials. Human capital within agriculture may thus be defined to include the years of field level experience in agriculture, variety and levels of academic qualifications in agriculture, the quantity and quality of agriculture-related technical skills, the communication and interpersonal skills of farm managers, the status of farm workers' health and their level of motivation (Saunders et al., 2010).

The OECD (2001) defined social capital as "the network of shared norms, values and understanding that facilitate co-operation within and between groups"(OECD, 2001). More simply, it relates to the way in which individuals interact (Ekins, 2000). Within the sustainability context social capital suggests that social bonds and norms are necessary for sustainability-related endeavours (Pretty, 2003). Where there exists a significant stock of social capital within a community or formalised group, people are more likely to have confidence in investing in collective activities and to consider others before

engaging in private actions with negative outcomes, such as resource degradation. Four social capital features are identified as important for sustainability aims: relations of trust; reciprocity and exchanges; common rules, norms and sanctions; and connectedness in networks and groups (ibid., p. 1913). At the farm level, the social capital stock of relationships of trust between farmers and institutions (including government agencies) interested in progressing sustainable agriculture appears essential for flow effects such as the exchange of information and the acquisition of knowledge that can facilitate the adoption of sustainability practices at the farm level. Farmers' engagements within their community such as through memberships of local groups may mean the building of the social capital stock of shared values and norms – in cases where these include environmental values and the norms of sustainability related behaviours – it may lead to flow effects that encourage farm-level practices that are in line with these (Saunders et al., 2010).

Cultural capital is a community's embodied cultural skills and values, in all their community-defined forms, inherited from the community's previous generation, undergoing adaptation and extension by current members of the community, and desired by the community to be passed on to its next generation. The cultural context in which shared attitudes, values and knowledge are passed from generation to generation is important in understanding the choices of individuals and groups (Dalziel, Saunders, Fyfe, & Newton, 2009). This was described as system memory by authors referenced earlier in this text.

Human-made capital 'includes fixed assets that are used repeatedly or continuously in production processes for more than one year'. These include tangible things 'such as machinery, buildings, roads, harbours and airports,' along with stocks of 'raw materials, semi-finished and finished goods held for sale.' Intangible types like computer software, and telecommunications are also included (United Nations, 2008, p. 49). In farm systems these are the infrastructure and machinery used in daily production along with farm produce and livestock.

Natural capital is generally regarded as consisting of three key categories: natural resources, land and ecosystems (United Nations, 2008; United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, & World Bank, 2003). All these categories are critical for long term development sustainability because of 'their provision of "functions" to the economy, as well as to humankind outside the economy and other living beings'(United Nations et al., 2003, p. 5). These functions may be categorised as follows:

Resource functions – Resources extracted from nature such as minerals, timber and fish for use within economic production systems being converted into beneficial goods and services for humankind (United Nations et al., 2003).

Sink functions – Nature's ability to absorb the unwanted by-products of production and consumption through three

Service functions – the functions of nature making up the habitat for living beings. These may be divided into two categories: (a) *survival functions,* comprising aspects of the habitat critical in the survival of biological beings such as oxygen and water and (b) *amenity functions* such as scenic landscapes, which are not necessary for survival but have both use and non-use values (United Nations et al., 2003).

As for using these capital based sustainability indicators to measure farm resilience, perhaps the most obvious gauge would be to identify non-declining capital stock over time. If these capital indicators are increasing within the farming system this could determine potential resilience to external and internal pressures or shocks.

For example, one might speculate that rich human capital at localised level could indicate flexibility and adaptability through the ability to innovate or diversify in the face of stress and in more adverse circumstances such as system changing shocks to rebalance and adapt to new regimes should they be necessary or occur.

Carpenter *et al* (2001) similarly suggest the use of surrogate resilience indicators. Like the capital indicators described above these surrogate indicators look at entire socio-ecological systems, not just certain subsystems. Emphasis is placed on the importance of these surrogates changing monotonically with resilience. Resilience surrogates focus on ever changing variables that underlie the capacity of a socio-ecological system to provide ecosystem services, where as other indicators often only address the current system state or service (Carpenter et al., 2001). Carpenter *et al* (2001) provide basic examples of surrogates but do not describe the different indicator types in any detail; meaning adaption of these to this study is not possible.

Sharp (2011) looks more specifically at quantifying financial resilience in agriculture using measures identifying resilient and risky conditions for the farm business. The author suggests that these 'risk to resilience' indicators can help provide an early warning system for potential problems. For each measure, risk and resilience are placed at opposing ends of the continuum indicating the farm's financial position. Through observing past indicators and comparing financial performance with standard guidelines, problems that may be developing within the farm business can be identified (Sharp, 2011).

These financial measures cover farm profitability, liquidity, solvency and financial efficiency. Sharp (2011) suggests profitability measures including rate of return on equity (risky- less than five per cent; resilient- greater than ten per cent); rate of return on assets (risky- less than three per cent; resilient- greater than eight per cent) and net farm income. Net income is difficult to compare across farm businesses due to it being an absolute amount and the subjectivity of business target incomes (Sharp, 2011).

Solvency measures identified were the debt to asset ratio (risky- greater than 50 per cent; resilient- less than 35 per cent); equity to asset ratio (risky- less than 50 per cent; resilient- greater than 60 per cent) and leverage ratio (risky- greater than 1:1; resilient- less than 0.75:1). Financial efficiency measures were operating expense ratio (risky- greater than 80 per cent; resilient- less than 65 per cent) and asset turnover ratio (risky-

less than ten per cent; resilient- greater than 20 percent). The suggested liquidity measure was the current ratio (risky- less than 100%; resilient- greater than 150%) (Sharp, 2011). Using these indicators alongside farm financial information could clarify how resilient certain farm businesses or industries are to internal and external pressures.

Analysis

This section will look at approaches and strategies implemented by New Zealand farmers to increase the resilience of their business. The information will be sourced from recently conducted (August, 2010) face-to-face surveys of farmers involved in the ARGOS (Agriculture Research Group on Sustainability) research programme. Where applicable, information will also be sourced from a survey conducted in August and September 1986 (Fairweather, 1987) to provide a comparison between strategies employed in both periods and changes due to an increasingly global economy.

The focal farm sector here will be sheep and beef farms of New Zealand's South Island. The ARGOS surveys were conducted in many of the South Island's key agricultural districts and with farms from the three main management systems, conventional, integrated and organic. Fairweather (1987), on the other hand, looked solely at the Clutha and Hurunui farming districts, taking a larger sample within these two regions without distinguishing the different management systems, it is believed that the majority were under conventional management (Fairweather, 1987).

In the 2010 sample there was some inconsistency in the number of responses to these questions as latter surveys included additional questions. The figures provided are also not representative of the number of farms surveyed as some respondents provided multiple answers to certain questions creating the appearance of more participants. It must also be noted that ARGOS data is collected from a cross-section of farmers from different management systems. For each of the farming districts a conventional, integrated and organic participant was selected, this gives an even spread across management types. However, this creates bias due to the disproportionate number of organic and integrated farmers in the sample. To provide a more realistic, generalised scope, conventional farmers need greater representation as New Zealand has approximately 44,000 sheep and beef farms with less than 1000 of these being organic. In addition the South Island only sample may not embody New Zealand wide perspectives on some of these topics. Also the small sample size may not be sufficient to provide a representative overview of the sector however it does give an indication of responses which could form the basis for further research.

In contrast, the 1986 survey looked at two South Island districts in depth. In 1986 the Hurunui and Clutha districts contained around 2000 farms with the overall response rate amounting to 17.3 per cent of the total farm population in these districts. This sample may not have been completely representative of the 60,000 farms in national primary production at the time but due to the clear majority of pastoral farms in both these

districts, it may represent pastoral farmers and their responses elsewhere (Fairweather, 1987).

When analysed alone, neither of the sampling approaches provide a direct indication of changes in attitude or response to the topics covered over time. However it is hoped that some of these views and strategies have been identified in the comparison conducted between the two time periods.

In the survey, farmers were asked to provide their coping strategies and reactions to economic changes and pressures. The first of these looked at the main source used to cover expenditure in times of need in response to an increase in costs or a decrease in returns.

Table 1: Main source(s) used to cover expenditure in times of need in response to an increase in costs or a decrease in returns

	2010	
	Number	%
Traditional financer only (e.g. Bank, meat company)	16	44
Family money	1	3
Other Government source	2	6
Off-farm work- spouse	4	11
Off-farm work- yourself	3	8
Sale of off-farm investments	1	3
Off-farm investment income	2	6
Sale of land	3	8
Unsure	0	0
Other	4	11
Total	36	100

Table 1 shows that almost half the farmers saw traditional financers, such as banks or meat companies as their means to covering expenditure in harder periods. For those in the position to do so another way in which some farmers responded to these phases was through tapping into external employment opportunities or supplementary income. About 20 per cent of farmers either did external work themselves or relied on their spouse's income to support the farm enterprise in times of financial hardship. To these farmers this was generally considered the best first option with other listed options only considered on a needs-must basis. Of those that listed sale of land as response, two saw this as a last resort. Expenditure reduction made up the large part of 'other' responses with these farmers preferring to adjust farm practices before seeking financial assistance from external sources. In times of certain environmental or physical hardship financing from government sources was also relied on such as government drought relief or accident compensation.

Table 2: Largest area of borrowing in past two years

	2010		**1986***	
	Number	%	Number	%
Have not borrowed	9	30	165	48
Additional land	3	10	25	7
New building	4	13	16	5
Livestock	1	3	16	5
New plant and machinery	5	17	22	6
Refinancing existing debt	2	7	52	15
Development	6	20	38	11
Other	0	0	12	3
Total	30	100	346	100

* Source: Fairweather 1987

In looking at the most significant area(s) in which farmers have borrowed in the past two years one can compare data collected from both the recent ARGOS survey and that for the same question in 1986. Analysis will be made of 2010 survey data with comparisons being drawn with those of 1986.

The figures in Table 2 show that 30 per cent of farmers surveyed have not borrowed in the last two years, this figure is however notably less than that of the earlier study where almost 50 per cent of farmers had avoided debt. The interesting thing here however is the areas for which farmers opted to borrow. The recent 2010 survey showed a significant percentage of farmers opting to invest in development while the 1986 figure was almost half this. These developments were predominantly in irrigation, with fertiliser programmes also factoring. Farm infrastructure was the other considerable area of development in 2010 while the number of farmers borrowing to purchase land was also noteworthy. In contrast to this the main area of borrowing in 1986 was in order to refinance already existing debt with 15 per cent of farmers opting to take loans for this reason. Other significant areas of borrowing were for development and land, these were however notably less than the percentage of farmers doing so in 2010.

Table 3: Preferred management strategy

	2010		**1986***	
	Number	%	Number	%
I have to change and diversify into new types of production	1	5	30	8
I have to change and adjust my present farming system	6	29	91	24
I have no choice but to stay with my present farming system	2	10	149	40
My present farming system is quite adequate	12	57	92	24
I have to look for ways out of farming	0	0	14	4
Total	21	101	376	100

* Source: Fairweather, 1987

With regard to farm management strategy there is a significant change in farmer attitude between the two time periods. As illustrated in Table 3, in the present day over 55 per cent of farmers felt that their current management system was quite adequate sounding as if they chose the situation they were in while in 1986 40 per cent of farmers stated that they had no choice, as if they were unable to change the circumstance they were in. In the 2010 survey farmers appeared quite content in the way they manage now with some noting their willingness to change or that their position depended on external influences such as prices. From the small 2010 sample a higher proportion of the organic and integrated farmers were of the view that they had to change and adjust their farming system accordingly than conventional farmers who were content with their current system.

Of the ARGOS farmers surveyed in 2010, 89 per cent had developed some or their entire farm in some new type of land use or management system. Of these over 40 per cent had developed their entire property. Those that had completely changed land use or management had either converted to organic agriculture, with over half having done this or other areas of specialisation such as intensified lamb fattening and increases in cropping. The farmers that made less significant changes generally appear to have diversified with conversion of sections of their property to other uses such as tree plantations, cropping, lucerne, deer and dairy leasing. One farmer had installed an airstrip for tourists providing off-farm work and returns. It can be observed from these figures that development of the entire farm property has generally indicated change in management system while smaller scale changes have tended to signify land use modifications.

Table 4: Management strategies considered or adopted in response to economic changes.

	2010				**1986***			
	Considered		Adopted		Considered		Adopted	
	Number	%	Number	%	Number	%	Number	%
A low input policy	0	0	19	76	48	12	245	64
Increasing farm size	5	20	13	52	66	17	19	5
Decreasing farm size	2	8	1	4	40	10	15	4
Increasing cropped area	1	4	6	24	40	10	48	12
Decreasing cropped area	1	4	0	0	26	7	28	7
Hiring more labour	2	8	5	20	23	6	5	1
Hiring less labour	1	4	4	16	32	8	125	33
Off-farm work	2	8	9	36	44	12	72	19
Using more unpaid family labour	0	0	6	24	26	7	120	31
Buying irrigation or other technology	5	20	11	44	19	5	12	3
Selling stock, plant, machinery, trees or other assets	5	20	7	28	30	8	62	16
Increasing stock carried	1	4	7	28	24	6	79	21
Decreasing stock carried	3	12	7	28	43	11	86	22

* Source: Fairweather, 1987

Table 4 lists 13 management options indicating the most common approaches used in response to economic change. Percentage figures here indicate the proportion of farmers that considered or adopted each option. The most common response in both time periods was to adopt a low input policy with 76 per cent in 2010 and 64 per cent in 1986 choosing this option in response to economic change. Interestingly, in 2010 increasing farm size and buying irrigation or other technology were the second and third most adopted options (52 and 44 per cent respectively) while in 1986 they barely featured (five and three per cent). In addition, increasing farm size had been considered by more

respondents in 1986 than anything else and in 2010 was considered most often along with buying irrigation or other technology and selling stock, plant, machinery, trees or other assets. On the other hand hiring less labour was often adopted in 1986 but was adopted far less in 2010. Table 4 shows quite significant differences in considerations and adoption between the two time periods, indicating considerable shifts in strategies in the 24-year time frame.

More specific additional details collected in 2010 suggested that livestock changes, which combined amounted to the most significant group, were most often influenced by weather and environment, with shifts in management direction also having a role. 20 per cent of farmers specifically stated drought as driving destocking. In addition, weather and feed quantity were noted as determining stock adjustments. Changes in management focus shaped stock flow with transition from livestock to cropping, bringing in off-farm dairy heifers, deer expansion and adjusting meat to wool orientation all being reasons for alterations to stock numbers. The additional input of water for irrigation also brought about change with farmers being less affected by drought or having the ability to expand, buying more land. Many farmers had taken advantage of unpaid family labour at some stage, generally in the past. Comparatively however, fewer farmers in 2010 (24 per cent) had made use of family than those in 1986 (31 per cent).

When asked which area of farm expenditure they would cut back on, more farmers opted to cut back on fertiliser than plant and machinery or repairs and maintenance. Plant and machinery were ranked second with repairs and maintenance placed third with some claiming they would carry out much of these themselves.

Of those surveyed in 2010, 75 per cent of farmers had developed new ideas or techniques to help them survive showing that innovation and adaption had enabled them to stay in the industry. A large array of ideas and techniques had been implemented including refinement of on farm management, farmer level marketing and utilising unique farm resources. Cutting back on expenditure and minimising inputs were seen as important. Using own labour and spending more personal time were identified as ways of doing this along with direct drilling, focus on yield and attention to efficiency. Others had chosen different directions, continually analysing products, looking to markets and companies they dealt with, diversifying and 'working backwards from that goal.' Working and meeting with other farmers to work out strategies for price making, share farming and farm rationalisation. Some respondents noted that they had learnt to stick with 'tried and true' practices and techniques, thus being 'thicker skinned' and less inclined to change.

Attitudes toward the processing and marketing of primary products were pretty consistent. There was a general consensus that both meat and wool industries in New Zealand need a basic overhaul. The only farmers that appeared reasonably satisfied with the meat sector (20 per cent) were some of those involved in organics citing the need for only minor changes. The wool sector however had the largest level of discontent with 90 per cent indicating the need for an overhaul with some identifying lack of demand as being the main problem. About 20 per cent of respondents felt that the cropping industry also needed an overhaul. Others however felt there was little wrong with the

organisation viewing the tough market, cost issues and competition as being the problem. With respect to the dairy industry, 50 per cent of farmers considered that organisation needed some minor changes to be satisfactory. Respondents talked about it appearing good but that it was mostly due to price, not necessarily organisational structure and how dairy gains a better response to the high New Zealand dollar. There was also concern expressed over international ownership within the New Zealand dairy sector.

Some opinion provided on how these sectors could be enhanced included an emphasis on product development and working on improving customer awareness of New Zealand's products. Using a single-desk approach to New Zealand's agricultural industries was also provided as a possible solution thus reducing internal competition.

In observing these results one needs to bear in mind that respondents were sheep and beef farmers. Some of these enterprises do and have the potential to include cropping and possibly dairy grazing; however for some their farm's location and terrain would not be suitable thus restricting their options.

Table 5: Financial resilience measures for the 2008/09 financial year

Measure (%)	Range	(Average)	Resilient	Risky
Return on Assets	-8 to 5	(0.1)	0	77
Return on Equity	-28 to 5	(-2.7)	0	95
Debt/Asset	-10 to 65	(16.6)	91	5
Equity/Asset	35 to 110	(83.4)	91	5
Operating Expense Ratio	36 to 149	(66.9)	64	23
Current Ratio	0 to 1452	(121.8)	13	75

Further to the management survey annual ARGOS farm financial figures were analysed using risk to resilience measures outlined by Sharp (2011). As financial surveys were conducted annually for seven years, figures from the 2008/09 financial year and seven year averages were observed.

The figures in Table 5 illustrate a range of measures and the variation between the different farms and their apparent resilience. The profitability measures of rate of return on equity and return on assets indicate that the majority of farms surveyed were in a risky position during the 2008/09 financial year with no farmers being in a position considered resilient. On the other hand solvency ratios (debt/asset and equity/asset) told a different story suggesting that most farms were financially resilient. The operating expense ratio measuring financial efficiency indicates that farm resource expenditure was at a resilient rate for two thirds of farms in 2008/09. The significant range in these financial figures also highlights the large variability between the ARGOS farms.

Table 6: Financial resilience measures based on seven year averages

Measure (%)	Range	(Average)	Resilient	Risky
Return on Assets	-6 to 4	(-0.5)	0	90
Return on Equity	-39 to 2	(-3.4)	0	100
Debt/Asset	-4 to 71	(18.2)	85	4
Equity/Asset	29 to 104	(81.8)	96	4
Operating Expense Ratio	43 to 160	(68.7)	54	21

In applying the financial measures to ARGOS seven year averages in Table 6, similar results were observed. Profitability measures continued to show farms as being at risk while farm solvency generally remained resilient over the long term. The operating expense ratio showed fewer farms being resilient however average figures showed little overall difference. An additional observation from the seven year panel data was that some farmers showing very high risk under a number of these measures have withdrawn from the panel and most probably the industry.

Discussion

From the analysis above a number of responses and trends can be observed along with some changes in farm strategy and management over the last 24 years. Whilst there were different conditions, both were periods of potential stress and change in New Zealand farming meaning similarities and differences could be compared both between time periods and in farmer responses.

The 1986 data was collected after the removal of agricultural subsidies and import tariffs in 1985; in addition, significant changes were made to the structure of the banking system, with increased lending restrictions, in the mid 80s. This was a period of unease within the farming community, with many farmers feeling pressures within their business. In the longer term the removal of farm subsidies have led to productivity gains, improving by an annual average of 5.9 per cent up until 2002. By comparison, the period before the removal of farm subsidies saw agricultural productivity grow at only one per cent (Agritech, 2002). In the 15 years following 1986-87, the value of economic activity in New Zealand's farm sector grew by over 40 per cent in constant dollar terms. Economic growth in the agricultural sector outpaced growth in the New Zealand economy as a whole (Agritech, 2002).

The current situation within the two main farming sectors within New Zealand is quite different to that of the mid 1980s and 1990s. At the start of this period sheep and beef farming was a more dominant sector. Since, sheep farming has seen the greatest change, with total sheep stock units falling from over 60 million to 40 million in 2002. Total stock numbers fell by around ten per cent between 1987 and 2002, but total productivity

from the smaller number of animals had actually increased. Cattle numbers had increased, with some dry-stock farms being converted into dairy farming and larger numbers of the annual dairy calf production were retained for dairy-beef production (Agritech, 2002). Many farmers who are still with sheep and beef offer dairy support in the way of dry cow run-off blocks, winter grazing and feed production.

The 2010 data was collected in the recovery period following the 2008 global recession. New Zealand lamb production had dropped as a result of previous de-stocking in response to the 2008 nationwide drought and low profitability, and sheep numbers were at their lowest level since 1946. While lamb prices in New Zealand's export markets were strong because of supply shortages from Europe, Australia and New Zealand, most farmers were experiencing recovery from the drought so were unable to benefit. There was also an absence of regular strong wool prices. New Zealand beef prices also came under pressure with increased competition in several markets. Beef export volumes were also down as a result of de-stocking during the 2008 drought (MAF, 2010).

In farmers' responses to the two surveys some of the effects of the hard times in both periods can be seen. Although the sample sizes and farm management types questioned were quite different, many of the responses were similar, despite two decades time divergence. There were however, also a number of differences in response to change or stress. These similarities and differences are discussed in detail below.

Results from the 2010 survey showed that in times of need, due to increased costs or decreased returns, 44 per cent of farmers still look to traditional lenders to cover expenditure. This would suggest confidence in the New Zealand financial system despite the recent recession or a desire to borrow rather than liquidating assets or using savings. The other option in times of financial hardship was the outsourcing of employment. This was either by the farmer themselves or their spouse. This displays how farmers and their families adapt to system stresses and diversify to remain in the industry. In doing so new skills are potentially learnt or knowledge gained meaning existing human capital is built on. This brings into play the idea of family enterprise and the system's preservation, rather than specific functions as outlined by Darnhofer (2010). A small number of farmers noted sale of land as a possible decision with most considering it as a last option.

The percentage of farmers who had not borrowed in the past two years for any area of their farm business in 1986 was quite high at 48 per cent. This is possibly due to a change in the structure of the banking system where they tightened on lending in the mid 80s. In addition this could have been due to the recent removal of subsidies and uncertainty of what the future held. The main area of borrowing was in the refinancing of existing debt, which could also indicate such concerns. This is in contrast with 2010 when, despite the recent financial crisis, 70 per cent of farmers had taken loans in the past two years; this is a very significant difference. This could suggest that there is confidence in the industry and that it will bounce back from recent downturns. With 50 per cent borrowing for development, machinery and building installation this may show that farming has become more industrialised and perhaps that debt is 'the norm' or necessary, even in times of hardship. According to Darnhofer (2010), avoiding

committing to large investments that might become unviable as the economic and policy environment change is one aspect of remaining flexible and adaptable in the face of uncertainty. If this is so, then farmers in 2010 may be less resilient to larger societal and economic changes they face in the future. However, no indication was given of the extent of the borrowing in each case, which would have a strong influence on the ability to withstand these stresses.

When questioned about preferred management strategy, there was a significant difference in attitude towards farming between the two time periods. There was an implication that there was no other way but that of the present in 1986, with 40 per cent of farmers saying they had no choice but to stay with their present farming system. This could be due to the recoil following the changes to subsidies with farmers feeling inhibited within their occupation. In contrast, 57 per cent of current day farmers found their farming to be quite adequate with additional comments implying they are content in the way they manage now. Farmers' belief of the need to adjust their current farming system was the most similar between periods, perhaps indicating that a number feel that they cannot predict all that has an influence on them and that being flexible and willing to adapt is necessary. This attitude could be in large part due to the ever-changing global market. The fact that a larger number of organic and integrated farmers held this view is possibly due to the less predictable niche market they are dependent on, meaning adopting new crops in conjunction with commodities.

The uptake of new land use practices or management systems by almost 90 per cent of the 2010 ARGOS sample was a clear indication that farmers have been happy to try new approaches or target new niches. What bought this about is less clear in many cases. For some this was through the wish to change management system, from conventional to organic for example. Others may have been as a response to stress on aspects of their existing system such as droughts or poor market prices. These changes in direction suggest a form of adaptation, whether for personal reward and fulfilment or in response to environmental disturbance or pressure. For some of the participants there is no clear suggestion of reasons for these developments, but for many of those of smaller scale it appears to be diversification of assets such as tree planting or airstrip installation for tourists. An important thing to note here is that the ARGOS sample was taken from a range of different management systems with a disproportionate weighting toward the alternative integrated and organic farming systems. The farmers in these management types are involved in new, developing and evolving areas so are probably more accustomed to change and uptake of new practices; this therefore creates a bias that does not represent the true balance of farm management systems within New Zealand.

Interestingly, employing a low input policy was the most common response to economic changes in both periods; however a number of other strategies also featured strongly. In examining the figures it appears that few had only considered this approach with the majority going on to implement it in their management responses. This would imply that it is perhaps the first line of defence when pressures or changes occur. When observing the 1986 figures, which mainly represent conventional farmers, this is quite surprising as in these management systems the approach is often that high inputs achieve high outputs. From these results this does not appear to be the strategy. Why the figures

showed this is not clear but it was a period of high pressure on all areas of farming meaning that perhaps farmers adjusted their regular management tactics to survive. Thus low input could well be effectively reducing costs.

The willingness to buy land or take on irrigation or other technology in 2010 participants was far greater than that shown in the 1986 figures. Over 50 per cent had actually bought land while over 40 per cent had bought irrigation or other such technology, in both cases an additional 20 per cent had considered such ventures. This investment could in part be a spinoff of the recent large-scale New Zealand dairy expansion in many areas, thus many sheep and beef farmers are offering grazing and run-off blocks for dry cows. In addition a number of farmers are supplementing their usual income by harvesting larger areas of hay or silage to sell as winter-feed to the growing quantities of dairy cows.

When combined increasing, deceasing or selling stock were a significant response to economic changes, representing a point where the farm resources were stretched or below capacity. Based on farmer comments this was often determined by environmental conditions along with management practices, such as drought combined with over-stocking leading to stock reductions. As farm resources recover restocking can occur, finance reserves permitting. Times of stress such as these will determine a farm enterprise's levels of capital and where weaknesses lie, as discussed by Young *et al* (2006) above. If its financial situation is strong then one could speculate that more stock and feed resources can be brought in and the business could survive. On the other hand, a farm in a poor monetary situation but with good natural capital, such as high soil fertility and pasture density may also survive due to reduced need to destock, indicating resilience through natural capital assets. Thus perhaps strong levels of certain capital assets can mean less necessity for strong or high levels of other capital, as one will supplement the other meaning the system remains resilience.

Solvency measures clearly suggested that the financial performance and resilience of most farms in 2008/09 was high with over 90 per cent being resilient using the measures described by Sharp (2011). This implies that the majority of farmers were capable of controlling their capital expenditure, debt servicing and family living expenses among other things. These solvency figures told a significantly different story to those of profitability which suggested the majority of farms were in risky financial circumstances and that no farms were at a resilient level of profitability.

No great difference was observed between the 2008/09 figures and the seven year averages. This was unexpected as those from before the 2008 global recession were predicted to be less conservative. The reason possibly being that it was too early for the real impacts of the recession to be apparent. Alternatively, perhaps for many farms, most of these financial measures don't display significant annual variations.

The operating expense ratio was the only seven year average that was obviously different with the upper range being higher than that in 2008/09, indicating that perhaps low input policies were implemented in 2008 in response to economic uncertainty. This was coupled with a reduced overall operating expense ratio meaning an increased number of farms were gauged resilient (a ratio of less than 65 per cent) in 2008. These

figures further indicate a reduction in farm inputs but the difference in the figures was not large enough for any certainty.

The withdrawal of some farmers from ARGOS can be linked back to the seven year averages of these financial resilience indicators, suggesting that consistently poor financial performance made the farm business unviable. This was seen where one farmer had the lowest average rate of return on equity and equity to asset ratio alongside the highest debt to asset ratio. Consequently this member withdrew from ARGOS after the 2005/06 financial year.

With these financial resilience figures being somewhat contradictory there is a need to identify measures that provide figures that are reliable and transparent in gauging the actual performance and resilience of the farm.

A large number of the ARGOS farmers had been innovative and adapted by developing new ideas and techniques to enable them to survive. These were wide ranging with some farmers having tried new approaches and having made the realisation that they preferred the way they knew while others were expanding and diversifying, investigating new markets, adopting new approaches to animal husbandry and trying new management systems. This represents the two main groups identified earlier, 'the content' and 'the innovative'. Whether one is more resilient than the other is difficult to determine as the 'tried and true' attitude is only developed through longevity and success. Being innovative and diversifying on the other hand has its risks with some new techniques not working and trends changing meaning loss of markets and revenue. In different ways both are based on past and recent knowledge and experience, which are considered important in enhancing system memory, seen by Cumming *et al* (2005) as an important facilitator in resilience theory. Possibly what this really indentifies is that whether farmers stick with the familiar and proven or remain flexible and adaptive, it is the management system or the strategies that best suit the farmer in question that really define whether their farm enterprise is resilient in the face of global change.

Limitations and Suggestions

As discussed above the data in the two samples are not commensurate. The ARGOS 2010 sample population is small and involved face-to-face interviews while Fairweather (1987) sampled a larger population but within only two districts. ARGOS interviews were conducted with a disproportionately high number of organic and integrated farmers, making up approximately one third of the sample each. The 1986 sample scope was more representative of New Zealand management systems.

The two samples also looked solely at New Zealand's South Island, which may have meant oversight of some attitudes and aspects specific to the North Island, such as those specific to warmer regions than exist further south. This spatial difference could be broadly highlighted by climatic differences with the tendency for the south and east to experience more droughts while the north is more prone to floods.

A major limitation of surveying and interviewing existing farmers about resilience was that it only provides a gauge of farmers who have survived; those that have made it through the external and internal stresses and shocks their enterprise was vulnerable to. In order to get the full picture one needs to sample those no longer in farming. This, it is believed, would provide a better indication of responses to disturbances that were effective and those that were not. This would require regular longitudinal surveying, attempting to provide a view as to what pressures or shocks where significant enough to induce system collapse. This would hopefully convey what level of stress, combined pressure or shocks can be withstood and possible give-way points.

Another limiting factor was that the financial risk to resilience indicators recommended by Sharp (2011) proved relatively contradictory suggesting there is the need to identify measures that provide figures that are a reliable and transparent representation of the actual performance and resilience of the farm. Consistent and trustworthy measures would enable clear and uncomplicated interpretation without the need for a thorough understanding of the farm itself.

Future research in this area requires the development of better approaches or techniques for measuring farm resilience that give more precise figures or levels, this is where development of resilience specific indicators could be worthwhile. These could be defined by the capital indicators mentioned above and based on the clusters of factors suggested by Berkes (2007) as important in building resilience.

A future area of research could be to extend study to other farm sectors. Extending the survey to cover dairy, horticulture and cropping farmers to see how responses and strategies are similar and differ between these strata. This could also incorporate a spatial component with comparisons of how flatland, lowland rolling and high-country farms diverge in their management systems and within certain seasons. This would work well with looking into farms in the North Island to see if any noteworthy differentiation also arises there.

Following on from the ARGOS interviews perhaps a larger postal survey would be the next step, thus gaining a greater sample and with a higher level of confidence. Perhaps even expanding to a biannual panel sample would be viable to show temporal variations with possible extension to include those that had recently moved on from farming to distinguish why and what determined the shift. In doing this a greater representation of conventional farmers would be gained which could clarify and answer some questions raised in this document such as whether low input policies are regularly adopted in conventional management systems or whether the 1986 survey was a one-off finding and specific to this particular period of hardship.

The inclusion of the duration of farm enterprises' existence within future survey and interview topics could also be feasible. The relevance of this is that how long an individual has been farming is perhaps a good gauge of the robustness of their management strategies and the subsequent survival of their business. This could link in the survival of family farms as opposed to new farm enterprises, incorporating questions

about interest and uptake by younger generations. This would contribute to information on whether the trend in aging farming population was continuing or changes were occurring.

Conclusions

Farmers adopt a number of different practices and strategies to ensure their continued survival, these are particularly important in periods of hardship. Strategies considered and employed are ranging and vary greatly from farmer to farmer and within different management approaches. These were observed in two forms, the resilience strategies put in place prior to disturbances and those implemented to remedy the effects of any perturbations or shocks. The majority of New Zealand farms surveyed were resilient to a large range of stresses and shocks, those that have been experienced first-hand in particular, with drought appearing the most common in survey responses.

Farm resilience was inevitably varying in degrees with some farms being attributed with more resilience characteristics, as developed through farmers' management methods. One of these characteristics was identified as a willingness to adjust practices when in times of hardship or economic stress. This indicates flexibility in management and farm activities with a strategy focused on the survival of the farm system as a whole, rather than maintaining certain individual production practices within it. This was seen in many farmers' adoption of technologies and activities that appeared to be angled toward dairy support, as this is where the agricultural industry is currently strongest. Another different strategy suggesting flexibility was the diversification of the farm with specialist niche development or conversion to organic farming.

However, it was also felt that in the current climate the majority of existing farms had a reasonable degree of resilience as they have survived in this irregular environment. A farmer who may be viewed as less adaptive or innovative, using proven traditional practices applies these approaches as they have withstood the changes and challenges the farm enterprise has faced.

Perhaps the most significant similarity between periods this research identified was that in times of hardship and economic change the majority of farmers employed low input policies, this was despite the two quite different survey groups. This was a relatively unexpected result, especially with the 1986 farmers and one that would be worth following up with further surveys and research.

The research also found that borrowing was far more common with modern farmers than it was in the mid 1980s. The majority of farmers had borrowed in the last two years with about half taking loans for farm development and equipment investments. The main reason identified for this was the recent injection of money into New Zealand agriculture by the increase in international demand for dairy, this has lead to large investments in development, buildings, and machinery on sheep and beef farms possibly with the goal to cater for dairy run-off blocks, winter grazing and feed production. The 1986 farmers were generally reluctant or unable to borrow with possible reasons for this being the

structural reform in banking at the time and uncertainty of what other changes and pressures may arise after the removal of both farm subsidies and import tariffs.

The risks farmers are willing to take also varied significantly. Some farmers were happy to take loans for developments or investments that they saw as bringing future gains. While others were prepared to be innovative and experiment with new practices, products or markets despite the potential for failure through losses of revenue or changes in markets.

So what makes a resilient farm and farmer? As is clear from the discussion above there is no one answer but if anything, the results of this paper show that it is the management system or strategies that suit the farmer that define the resilience of their farm business and ensure its survival in an ever changing global marketplace.

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