Response of Dairy Farmers, Industry and Government to Drought in the Grey Valley, West Coast

An inquiry into environmental circumstances and multi-level management

Jessica Pullen

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Abstract

Intensive dairying is a developing industry in the West Coast economy but has been a source of employment to the region since the early 1900s. Despite having the highest rainfall anywhere in the country, the West Coast is still subject to climatic variations and experiences drought-like conditions, especially the event that occurred over the summer of 2012-13. The objective of this study is to evaluate the response strategies of farmers, industry and local authority during the 2012-2013 summer drought event and understand what approaches could be used to manage future drought conditions in the region. The key factors analysed were environmental components, such as soil type, topography and climate, along with the management and farming system components, such as irrigation, dairy pay-out and multigenerational management. Three key responses undertaken by farmers were the establishment of irrigation, on-farm and externally sourced supplementary feed, and dropping to once a day milking in the early stages of a drought event. The size and location of the farms did not show any clear links to the response strategies but rather farmers responded according to the characteristics of their property and individual circumstances. The dairy pay-out played a large role in the decision making process of the farmers and introduced constraints on what response and management strategies could be implemented at a farm level. The role of the industry and local government informants were primarily advisory, support and regulatory roles but did not participate on any farm level assistance. The Grey Valley has the opportunity to develop drought response policies in reaction to this event, as this is the direction that modern drought responses have taken in international case studies, replacing the reactive, responsive element with the overall management of drought risk. Thus there is the opportunity to urge farmers to incorporate sustainable water management into their farming strategies that is designed around the available water resources. By decreasing risk, drought vulnerability will decrease accordingly and the adverse impact of the water scarcity may be mitigated.
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1 Introduction

Agriculture plays a critical role in both national and global economies providing food resources and employment for rural and urban communities. Despite the increased intensity of agriculture and the amount of agricultural produce being sufficient to feed the world’s population, the most significant issue is the distribution of these resources to those living in unfavourable agricultural conditions (Hazell and Wood, 2008). The increasing intensification of global agriculture has put extensive pressure on the major global producing regions with many experiencing land degradation and widespread water deficits. Agriculture is the world’s biggest consumer of fresh water resources making it proportionately more vulnerable to the associated risks of any changes in rainfall as a result of climate change (Calzadilla et al., 2013).

As these issues become increasingly relevant, research on sustainable agriculture and adaptation to climate change is needed to protect future world food supplies vulnerability to climate change. The objective of this study is to investigate the actions at multiple levels in an agriculturally dominant region in New Zealand, that experiences infrequent water shortages due to its high average rainfall. The West Coast of New Zealand infrequently experiences drought, but has undergone the initial stages of drought management and response in light of a recent intense drought in the austral summer of 2012-2013, and provides the opportunity to explore response strategies of the dairy farmers in the region, who have varying levels of drought management experience.

Climate change is a topic well known by the world’s scientific community with an increasing awareness within the general public. Climatic scenarios have been developed that indicate that the consequence of changes in global climate will range from severe storms and extreme rainfall events to extreme and extensive drought events (UNISDR, 2009). The extreme natural hazards associated with these events adversely impact many regions around the world raising the issue as to whether these will remain infrequent “extreme events” or considered climatic variability. Drought is quickly becoming the single most widespread natural event, with destructive results putting pressure on both global ecosystems and agriculture (Leblanc et al., 2009; Fig. 1.1).
The threat of deleterious weather patterns due to climate change has put agricultural regions who have suffered water scarcity, under pressure to develop practices that incorporate climatic changes into future agricultural policy and water resource (Boutraa, 2010). Changes in drought perception in a number of regions from ‘extreme weather events’ to recurring climate variability is an indication of acceptance that water management practices need to adapt to accommodate for recurring drought. An example is the Australian public who have exhibited a changing attitude toward drought and what needs to be done to manage it, especially in Australia’s south-eastern regions (Dijk et al., 2013). Risks to water resources are particularly acute, with an acceleration of the hydrological cycle indicated with anthropogenic climate change. Such changes may be expressed as increased incidence of drought, and increased risk to physical and/or economic water scarcity.

There has been on-going debate regarding how to classify a drought and what defines it. A formal definition of a drought is difficult as it incorporates so many components such as rainfall, soil moisture, surface water, groundwater and temperature. Drought is a natural hazard due to unusually low rainfall that cannot be controlled or managed. By comparison, water scarcity is a lack of water resources due to unsustainable use and mismanagement, but it can be controlled and mitigated with better management practices (Van Loon and Van Lanen, 2013). According to Van Loon and Van Lanen (2012) drought is either a
hydrological or a meteorological drought with each having separate characteristics. Meteorological drought refers to those caused by a lack of rainfall over an extended period, which eventually results in a hydrological drought. Hydrological drought, however, is a lack of water resulting in a deficit in soil moisture, groundwater and discharge. The classification of drought into meteorological and hydrological is referred to in publications such as Botterill (2003) but can also be defined as a temporal or spatial drought as referred to by Maracchi (2000).

The impacts of drought on economic development is a challenge many agricultural producers around the world are facing impacting the local communities who make a living off agricultural activity, right up to global produce trades. Droughts in primary agricultural regions, such as the Murray Darling Basin and the western states of the USA, are just a small number of examples that portray the potential severity of drought impacts on economic development. Regions of Latin America, such as Brazil, have also experienced numerous droughts in the past, which have adversely impacted the production capabilities of major agricultural regions. Despite the extensive droughts that have occurred, there have been insufficient resources put into the response strategies resulting in 33% of the overall decrease in Brazil’s agricultural production being attributed to drought between 1991 and 1994 (Orivaldo et al., 2005). The increased frequency of drought related impacts on agriculture has also resulted in an emphasis on identifying particular farming practices that may not be as severely impacted by regional climate changes as others. By strategically producing specific products in regions with favourable conditions, agricultural practices are being modified to suit the conditions as an alternative to attempting to modify the conditions to suit the practices (e.g. irrigation, land modification). For instance, some crops have increased production with changes in regional climatic conditions (Fig. 1.2).
It is these adaptive strategies at a regional scale that will ultimately determine the success of agriculture and agriculturally dependent regions. Crop diversification is a common practice that has been implemented by numerous agricultural regions in an attempt to increase resilience and ultimately mitigate the impacts caused by environmental variability (Lin, 2011). A major benefit for farmers is the advantages of the continuously improving technology that can be incorporated at a farm level to maintain production at a sustainable level, in addition to increasing water use efficiency. Knowledge and experience is a significant component that must be applied on farm to improve sustainability. The switch from short-term based actions to long-term resource management is an approach being adopted extensively and could be how sustainable agriculture is achieved in the future, being an on-going strategy for regions like Australia’s Murray Darling Basin (Mpelasoka et al., 2008). Despite the continuing developments and improvements being made, the overall impact of climate change related water scarcity is predicted to have a major impact on the accessibility of food, especially to drought impacted poor developing countries in northern Africa and Asia who will need to rely increasingly on imported food resources.
(Schmidhuber and Tubiello, 2007). An overwhelming theme identified in a large proportion of research is that drought will continue to adversely impact the agricultural regions of the world but those who will continue to be the most severely impacted will be the world’s poorest regions who already struggle to access sufficient food resources (Schmidhuber and Tubiello, 2007). A collective effort from authority, industry and farmers would result in an extensive pool of valuable and practical knowledge that could assist with the impacts on agricultural regions, both large and small, and may provide a framework that multiple regions could adapt and implement. Although policy will always play an important role in future drought response and management, it will be just as important for those at farm level to be engaged in a multi-level response strategy. Open and co-operative communication between all involved is essential to achieve a desired result for both an immediate drought response and management for future events and overall climate variability.

With the increase in droughts occurring comes an increased focus on how the various agricultural industries should respond and what can be done by the farmer, industry and local/national governments to mitigate the adverse impacts of extensive drought. Although there are regions that have adapted to the conditions associated with frequent drought events, there are those that are only just beginning to feel the strain of limited water resources. The result of drought scenarios is a struggle to maintain a profitable business with a decrease in production and an increase need for external resources and assistance. With increased potential incidence of drought into marginal and new areas that are perhaps not adapted to regular drought, there is a need to research strategies to identify the effectiveness of response strategies from regional case studies and adapt these to new areas that may become increasingly vulnerable to future drought.

### 1.1 Thesis Outline

The objective of this thesis is to determine the response strategies of the Grey Valley dairy farmers, industry members and local government to drought with particular emphasis on the drought event that occurred in the region from January–March in 2013. This drought event was used to investigate what response strategies were applied during the event and
also to assess the impacts that the event might have on the response and management of future events. Supporting case studies from other agricultural regions were analysed to understand how the response of Grey Valley farmers to drought fit with responses from other major agricultural regions, with emphasis on case studies from the Murray Darling Basin in Australia and the Great Plains of the USA. Studying the weaknesses and strengths of past responses of agricultural regions to drought from previous case studies can be utilised to improve future drought response along with better overall water management. The investigation of the literature in addition to the information gathered during the interviews conducted in the Grey Valley, illustrated a picture of how farmers, agricultural industry informants and governments responded to changes in physical and environmental conditions and attempted to maintain production and preserve local, national and global economies during drought. Research of this nature is important not only to the major agricultural regions of the world, but also to the smaller regions, such as the Grey Valley on the West Coast of New Zealand. It is crucial that resources are applied in smaller regions, such as these who are in the initial stages of drought management, to install sustainable and water efficient farming practices into the foundations of future drought response and management. To achieve the objectives of this study the research questions had to reflect current and future actions that are being applied and considered by the farmers, industry and local government. The foundations of this research were based on the following questions that were asked during the interviewing process:

- What were the impacts of drought on farmers considering financials, stock welfare and ability to farm?
- Did the severity of previous drought events cumulative effect on farms within the Grey Valley?
- What strategies do farmers put in place to mitigate the adverse effects of a drought event in the Grey Valley?
- What strategies does the industry put in place to mitigate the adverse effects of a drought event in the Grey Valley?
- What strategies do local and national governments put in place in to mitigate the adverse effects of a drought in the Grey Valley?

The thesis is divided into seven chapters. Chapter two examines drought management and response strategies to develop an analytical framework for discussing the response strategies in the Grey Valley. The third chapter provides a context of the study site chosen...
giving historical, industrial, geographical and environmental information about the West Coast with emphasis on the Grey Valley, providing a comprehensive understanding of the study site, and is followed by a brief chapter that summarises the research methods used to collect data for the study (Chapter 4). The results found during the study are summarised in Chapter 5, as well as providing contextual interpretation of the data and discussing the key themes that developed from the key informant interviews. Chapter six synthesises the key findings of the research and provides recommendations for future management practices on the West Coast for developing drought resiliency.
2 Drought Management and Response Strategies

Chapter two investigates the drought response strategies developed from case studies from agricultural regions all over the world. The two major regions that have been analysed are the Great Plains of the USA and the Murray Darling Basin in Australia. The use of these two case studies is due to their long history of drought response allowing the development of their strategies to be documented in literature and policy. Smaller agricultural regions whom are focussed on providing food resources at a far more localised scale were also included with any similar themes between them and the larger agricultural regions identified.

2.1 Regional Drought Response Strategies

Drought response have been analysed by the investigator at three levels – farmer, industry and local government. The combination of actions from these parties is important when determining the overall response of a particular region and to understand how the priorities and perceptions of the parties influence the decision making process. As the frequency of drought increases, it has become increasingly important to ensure that individual farmers, industry and government make appropriate and well-informed response decisions. There are a number of approaches to mitigate the impacts of drought events on global agricultural industries, some are well established and some that are still being developed. In the following sections, preventative/adaptive and post responsive strategies are identified as ways to characterize responses to drought, with numerous actions and measures being made to achieve the objectives of each strategy. Although many of these response strategies are often generalised, it is important to analyse drought scenarios at a smaller scale and to consider the specific circumstances of individual regions being affected. Increased understanding and familiarity to these responses will be the key to their successful implementation to individual cases.
2.1.1 Federal and Regional/State Government Drought Response

As drought events around the world are becoming more persistent and severe, response strategies have had to evolve and change to achieve the desired result for farmers. The responses have mostly fallen into one of two categories, proactive or reactive drought response. The response strategies that are classified as “proactive” are implemented to try to mitigate the adverse effects of a drought prior to the event. The idea of proactive response was reiterated by (Wilhite et al., 2000) who described it as being “defined as short and long term actions, programs or policies implemented during and in advance of drought that reduce the degree of risk to human life, property and productive capability” (p. 698) Appropriate drought response and planning also relies heavily on predicting the extent and severity of a drought event. The primary challenge associated with drought prediction is identifying a drought with enough time to allow preparation measures to be put in place and be effective (Luo and Wood, 2007). Although improvements have been made in forecasting these events with increased understanding of processes, such as the El Nino and La Nina cycles, on-going emphasis is continuing to push techniques to improve the understanding of drought prone climates. Investing in drought forecasting research will be important in developing the behaviour of farmers and allowing them to have the opportunity to make appropriate preparations to mitigate adverse effects. To explore these strategies further, the approaches taken in different regions are presented below, to in part, account for their different governance and response approaches. The primary case studies that are concentrated on are those associated with the extreme drought scenarios such as California, USA and the Murray Darling Basin, Australia. Most of these proactive response strategies have been developed in countries that have undergone multiple drought events allowing them to learn from the weaknesses of previous responses (Ballard et al., 2014). Many of these proactive actions are related to the reduction of water allocations to encourage farmers to manage the resource more effectively and sustainably.

2.1.1.1 Case Study 1: Australia

Drought has been a large part of Australia’s history, impacting major agricultural regions, especially in the south-eastern states surrounding the Murray Darling Basin. With consistent development in drought management and policy, the Australian government, both at a state and national level have made progress with how they respond to drought and manage the associated risks. Despite these efforts, drought is still a phenomenon that has
plagued the Australian agricultural industry and still does so today with one of the worst known droughts to be the multiyear event that occurred between 2001 and 2006 (Leblanc et al., 2009).

A study carried out by Wilhite (1986) compared the response strategies of Australia and USA governments to the increasing frequency of drought events in agricultural regions. The study identified quite different response strategies between the two countries, highlighting Australia as being, at that time, far more proactive, learning from previous drought events that have impacted the region. These responses took place both on farm and at state and national authority level, ranging from the farmers attempting to improve water management and stockpiling feed to government enforcing new, more stringent regulation to ensure farmers are aiming for sustainable water use. The approach to the issue at a government level is based on risk management and decreasing farmer vulnerability to drought events. An example of this is the 10 step planning process (Fig. 2.1) that was developed by Wilhite in 1991 for U.S. drought management and has been tailored and modified for use in a number of drought prone countries including Australia.

By comparison, the USA government tended to be more focused of the “crisis management” of extreme drought events while Australia showed extensive measures to be prepared, consistently evaluating the situation and ensuring that preventative procedures were always in place as a precaution (Wilhite, 1986). This allowed Australia to be global
leaders in drought responses, with a program that was pre-adapted and easily implemented when needed. As drought still continues to plague many regions in Australia, the government has had to shift their approach from short-term crisis response to long-term risk and vulnerability management (Botterill, 2003). Measures taken by the Australian Government are still being implemented and developed as drought continues through into the 21st century (Leblanc et al., 2009). The Murray Darling Basin is situated within three states (New South Wales (NSW), Victoria (VIC) and South Australia (SA)), each with their own set of policies and regulations around water use and extraction. During the initial responses of the early occurring droughts, the policies that were initially established in the 1930s were at a state level, with different sections of the catchment being governed by different authorities. The regulation inconsistencies of the catchment resulted in the effectiveness of overall management strategies being flawed and not achieving the level of mitigation that was needed (Kiem, 2013). In an attempt to improve drought response in the Murray Darling Basin (Fig. 2.1), an area specific group was initiated and given authority over the water management for the entire catchment (Ballard et al., 2014). As the catchment is situated within the three states New South Wales (NSW), Victoria (VIC) and South Australia (SA), the integration of state and national level government was paramount in improving the existing water management of the area (Ballard et al., 2014). As a result of this the Murray Darling Basin Plan was created to manage the Murray Darling Basin as its own independent zone and was made up of representatives from all three states (Kiem, 2013).
The MDB is a clear example of the implications of non-sustainable practice, and extensive research by drought response experts have suggested that the region will not have the water resources to support the current level agriculture that currently relies on it as a primary water source (Kiem, 2013, Ballard et al., 2014). Although Australia’s drought responses have been considered proactive compared to those undertaken in the USA, unsustainable agricultural activity has resulted in the Murray Darling system only flowing at 23% of its total capacity (Leblanc et al., 2009). The integration of national and regional scale government has resulted in plans and policies at various levels but the balance between the two has proven to be a complicated task (Ballard et al., 2014). Regardless of these issues, numerous policies and projects were initiated with funding being provided at both national and state level. Some of the initiatives drafted included:
• “Driving reform in the basin”

The Driving Reform in the Basin is a program that supports the Australian Government contributions to the actions made by the Murray Darling Basin Authority. It incorporates the regulations that fall under the Water Act 2007, the Water Market and Water Charge Rules and the Water Amendment regulations 2010. In summary, this program has been put in place to provide a link between national government and state governments currently managing the Murray Darling Basin (Department of Environment, 2015).

• Sustainable Rural water use and infrastructure programme

The Sustainable Rural water use and infrastructure programme is a collection of projects that have been put in place to attempt to improve the infrastructure and subsequent water use within the Murray Darling Basin at both a state and national government level. A number of these projects have been put in place to increase understanding of the water resources and provide guidance as to what would be the most efficient and sustainable of utilising it. Some examples of these projects include the on-farm irrigation efficiency program, Murray Darling Basin Regional Economic Diversification Program, and the Victorian Farm Modernising Project (Department of Environment, 2015).

• Murray Darling Basin Sustainable Yields Project

The Murray Darling Basin Sustainable Yields Project was a basin scale investigation into the availability of water resources in the Murray Darling Basin. The objective of the research was to determine the impact of catchment development, groundwater extraction, climate variability and climate change on the available water resources within the Basin. The assessment carried out by The Commonwealth Scientific and Industrial Research Organisation (CSIRO) provided the state and national level government with extensive data that could later be used in designing and publishing legislation that would preserve water resources in the Basin (CSIRO, 2008).

The purpose behind the above three programs has been to increase understanding of the resource, and improve communication between national and state government and
implementation of the appropriate regulations and policies. Together the three programs are a proactive approach to any future drought event in addition to the current situation in the Murray Darling Basin. These three schemes were all involved with the mitigation of drought impacts on agricultural communities in the area and were followed by numerous more that focussed on other aspects of the basin including ecology, water quality and soil condition (Kiem, 2013, Ballard et al., 2014). Funding allocations were made within many of these plans, for example $5.8 million was granted to the sustainable rural water use infrastructure project whose focal point was to improve and upgrade the irrigation technology being used (Ballard et al., 2014).

![Figure 2.3](image)

**Figure 2.3:** Cumulative rainfall deficit across the Murray Darling Basin for the 2001-2006 period and location of the shallow groundwater monitoring bores. Source: Leblanc et al. (2009).

Although the Murray Darling Basin drought events are the most well known in Australia (Fig. 2.3), there is a large expanse of the country that regularly experience extreme drought conditions. The methods adopted by the national government allow the state level government to customise their own drought responses according to their climate, industry land use, soil types and water demands (Ballard et al., 2014). Many of the drought responses undertaken in Australia were done so in crisis mode during the events where decisions were made in high stress and emotive circumstances. Undertaking decision-making in these circumstances could potentially impact the judgement of the decision makers involved in the government response process (Kiem, 2013). Over the last century,
Australian drought response strategy has undergone numerous developments in an attempt to mitigate the impacts of regular and on-going drought. Up until the 1980s the drought events were categorised as natural disasters and the responses were considered to be disaster relief (Kiem, 2013). As the events became a regular occurrence, the approach to drought response changed from disaster relief, to the management of changing climatic conditions. The incorporation of anthropogenic climate change is a topic of discussion among policy makers as they considered approaches to prepare for long-term climatic changes in high intensity agricultural regions, such as South Australia and New South Wales. The idea of incorporating climate change adaptation introduced uncertainties and lack of data that is associated with climate change, making it difficult to apply to a reliable and robust drought response and water management policy (Kiem, 2013).

Recent research on droughts in Australia use complex computer modelling systems to establish the specific figures involved with adverse impacts. National agencies, such as CSIRO, have played a fundamental role in the development of drought prediction models, with the current mk3.5 model being used to assess the variations in predictions made by other global climate models. The information gathered by such a model is valuable to water management resource strategies, giving an indication of what to expect in the case of future drought events (Johnson and Sharma, 2009). In response to the drought between 2002 and 2003, a complex economic model was developed to determine the responses of different economic sectors (Johnson and Sharma, 2009). The model used was pushed ahead by policy makers and helped to predict the success of crops in addition to being implemented to consider the individual condition of each state. This allowed economists to establish individual economic scenarios (Horridge et al., 2005).

Australian specific model TERM (The Enormous Regional Model) assisted both state and federal government in understanding drought, not only in the context of water management, but the impact of a drought on economic conditions and the markets that depend on the produce of effected regions (Horridge et al., 2005). As a consequence of the 2002-2003 drought events an 8% drop in national employment and a 21% drop in gross production were estimated. Figures such as this allow authorities to determine the most severely impacted region so they can effectively prioritise their attention and resources to the area, and people who are most in need (Horridge et al., 2005). The decrease in production not only impacting the farmers, but also contractors and transport businesses.
whose employment depended on consistent produce supply. Modelling tools and subsequent regionally specific information such as that provided by TERM, contribute information needed for an informed response to the areas that required resources and on-going support (Horridge et al., 2005, Johnson and Sharma, 2009). The most significant actions taken by government revolve around using data and experience from past events to reform policy and regulations that surround water takes from individual catchments such as those in the Murray Darling Basin. Although assistance during drought in the form of feed, free transport to slaughterhouses, and continuous advise have previously been implemented (Wilhite, 1986), the increasing frequency, extent and management approaches of the events are phasing out these types of responses and replacing them with a support structure which assists farmers to be self-reliant and improve their overall water management, ultimately making them less vulnerable to drought (Kiem, 2013). Encouraging farmers to adapt more sustainable water management and assisting in the establishing the infrastructure to do so would be a far more effective way of supporting farmers in the drought ravaged regions in Australia, as well as preparing those in less vulnerable regions for potential drought in the future (Kiem, 2013). Preparing a drought policy that has clear and concise objectives that can be understood by those at all levels is important to achieve cohesive and joint actions to decrease agricultural vulnerability to drought. Australian governments implemented the National Drought Policy in 1992 with the following objectives:

- To encourage primary producers and other sections of rural Australia to adopt self-reliant approaches to managing for climate variability;
- To maintain and protect Australia’s agricultural and environmental resource base during periods of extreme climatic stress;
- To ensure early recovery of agricultural and rural industries, consistent with long term sustainable goals.

Many of the key terms used in reference to drought management such as self-reliant, maintain, protect, recovery, sustainable are implemented in this document and contribute to it being one of the most robust and adaptable drought policy statements to date (Wilhite, 2005). The manner at which this policy has been designed is based on the concept of allowing farmers to become more self-reliant instead of repetitively providing relief that would only benefit farmers in the short term (Wilhite et al., 2000). Adopting plans based upon risk management and vulnerability will encourage government to adapt
policy to drought and continue learning from weaknesses identified in the past (Wilhite, 2005).

2.1.1.2 Case Study 2: United States of America (USA)

High profile cases that have been referred to in drought response research include those that have occurred in the USA, with particular emphasis on states such as California. The studies carried out in California have been published over more than a century and have captured the developments of drought response strategies of both state and national government (White et al., 2001). The USA federal government has had drought response methods since the series of severe drought events in the 1930s with emphasis on the Great Plains (Wilhite, 1986). The drought responses for the events until those that occurred in the early 1970s were carried out primarily by the Federal Government with very little state government involvement (Wilhite, 1986). As droughts became a more frequent occurrence through the 20th century with unsatisfying improvement in response effectiveness, the incorporation of efforts by both state and federal government became especially important (Wilhite and Rosenburg, 1985). Similar to the early Australian responses, the USA federal and state governments carried out most of their drought response strategies during or post event, acting in a more “crisis management” manner. Crisis management is based on providing relief in the later stages of the drought when the impacts are being felt the most, examples of crisis management are what is included in the assistance packages provided to farmers such as emergency feed, subsidies on transport and culling costs and emergency loans (Wilhite, 1986). The main objective of the developments in drought response policy is to reduce the risks and vulnerability of farmers by implementing state level drought plans that identify and incorporate the relevant risks associated with each individual state and allowing them to be assessed, monitored and mitigated appropriately (Wilhite et al., 2000).

As the drought events in the western states of the USA have impacted the agricultural sector throughout the 20th and 21st century, the response strategies have changed and undergone improvements with increased experience in drought management. The most significant change that has occurred is the approach to drought response being switched from a reactive response to a more comprehensive, prepared and long term drought management plan (Wilhite et al., 2000). In addition to the response strategies that took
place in the early stages of drought response management (1930-1970s) the recent advancement in modelling and forecasting technology has allowed for research to improve the awareness of drought processes (White et al., 2001). The introduction of these techniques has improved the understanding of the drought-induced impacts on the specific natural water resources and soils ability to provide desired production. There are a number of regions in the USA that have suffered from extensive drought that have had adversely impacted agricultural industries leading to new techniques that incorporate modern technology, such as water analysis and drought risk models. Many of these models have been designed to estimate the amount of water resource there is available for agriculture, and how much is needed to preserve and protect productivity and what can be used sustainably (Hornbeck and Keskin, 2014). Modern technology including pumping capability has increased the accessibility of many agricultural regions, especially those in the western states which have integrated these new technological advances to reach water resources that have not previously been accessible (Hornbeck and Keskin, 2014).

Figure 2.4: Farmers in California’s Great Valley carrying out irrigation supplied by groundwater pumping. Photo Credit: Dennis Dimick.
Groundwater quickly became a primary source for irrigation of crops in the Central Valley of California (Fig. 2.4), and with the increasing accessibility came an increased reliance of farmers on the new source. In the last century aquifers have been depleted by ~50% provide water sources for ~60% of the irrigation in the USA (Scanlon et al., 2012). In an attempt to secure the water needed to maintain agricultural practices, recent modelling techniques have been developed and utilised to determine the viability of groundwater use during drought conditions (Medellim-Azuuara et al., 2015). There were concerns around the over exploitation of groundwater, and the threats that it has on the viability of groundwater being a source that can be preserved for future use during drought. A series of models were developed to understand the impact of groundwater extraction on the surrounding environment and to comprehend the water quantity that can be extracted sustainably (Hornbeck and Keskin, 2014). The addition of these modelling programmes have allowed for new data to become available relating to the amount of groundwater that could be sustainably used without adversely impacting the overall groundwater source (Hornbeck and Keskin, 2014). It was estimated, for example, that during a drought event, farmers could extract up to 6.2 billion cubic metres annually during the event without compromising the on-going availability of the water (Medellim-Azuuara et al., 2015). This calculation was achieved with the assistance of two independent models – SWAP and CVSim, both of which have given an indication to industry about what policies and restrictions may need to be put in place for groundwater use in California’s Central Valley during a multiyear drought event (Medellim-Azuuara et al., 2015). Conflicting studies have, however, suggested that groundwater is not considered a renewable source and sustainable consumption is no longer realistic (Gleeson et al., 2015). The reasoning being that it takes time for groundwater sources to recharge with estimates indicating that the majority of groundwater may exceed a 50 year period to recharge (Gleeson et al., 2015).

Initially, the central government was responsible for designing drought response strategies and as a result created what was known as the Great Plains Conservation Program. Later, however, the spatial scale of these events drove the formation of drought support services that were tailored to fit the severity and circumstances being experienced by each individual state (Wilhite and Rosenburg, 1985). There were numerous components that made up these support services that were adapted to assist with each individual state needs. Although the assistance was primarily loans based on eligibility criteria, the general trigger for farmers to be eligible for financial loans was if production losses during the year of the
drought exceeded 20%. Additionally to these government loans, farmers were also given access to;

- Emergency livestock feed,
- Feed transportation,
- Cattle transportation,
- Unemployment insurance,
- Technical advice.

There are numerous government agencies that were formed and that are still involved with these types of relief efforts offering differing levels of assistance, depending on the vulnerability of the farmers or the severity of the event (Wilhite, 1986). Such approaches were also demonstrated by states such as Georgia. Emergency procedure in the past have included the movement of large scale water resources and creating a “hay hotline” where those in the farming community could ask for assistance in the form of feed (Wilhite, 2005).

A severely crippling drought event experienced in the Great Plains in 1996 was followed by a sense of urgency to have a more robust drought policy in place. The result of this was one of the most revolutionary drought initiatives in North America’s history, The National Drought Policy Act (White et al., 2001). With the collaboration of multiple national scale agencies, such as the Federal Emergency Management agency (FEMA) and the Western Governors association, arguably the most robust and prominent legislative drought policies were made operative (Wilhite et al., 2000; White et al., 2001). One of the primary objectives of this policy was to fashion a fluent and easily implemented management plan to quickly and efficiently respond to a drought event (Wilhite, 2005). To achieve this, a number of updated financial aid and insurance packages were outlined, in addition to having a system for farmers to apply for aid packages to assist with feed scarcity or ability to cull animals (White et al., 2001).

Although the post drought response strategies do vary from region to region, the nature of assistance follows a similar trend. In North America, loans and discounts for services, such as freight and emergency feed have proven to be commonly used in addition to time extensions for taxes (Wilhite, 1983). In extreme circumstances, assistance to sell or move stock to slaughterhouses were also offered to farmers as animals began to lose condition and animal welfare begins to become an issue (Heathcote, 1988). These forms of
assistance have been offered for almost half a century and are still offered to current
drought stricken areas within the USA (White et al., 2001). This is an indication that
current drought response in the USA does still follow the post-response strategy and it is
still seen as an effective approach.

2.1.2 Smaller Rural Community Responses

The implications of drought in smaller communities are the impacts that the events have on
the availability of food resources at a local scale. This is the cases in the farming
communities of numerous African countries including one of the most severely droughts
stricken - Kenya (Campbell, 1999). The Southern Kajiado District in Kenya is home to
numerous small scale farmers and herders whose production is purely for their own
consumption and studies have been undertaken to determine the drought management
techniques of a farm that is non intensive and focuses primarily on the farmer’s family and
community. A key theme that has occurred is the ability of these communities to adapt to
the changing climate to maintain production that is sufficient enough to provide the
required food resources (Kabubo-Mariaya, 2005). The national and local governing bodies
have focussed on these farmers ability to work the land without any major degradation that
may amplify the effects felt during a drought (Campbell, 1999). The overall concepts
highlighted by the authorities are similar to those displayed in other large scale agricultural
regions even though they do not possess the same financial or research based resources and
information. A key aspect that needed to be taken into consideration was the cultural
values that were associated with the existing farming methods (Kabubo-Mariaya, 2005).
Agreements were made between the policy makers and locals that ensured that the changes
that were made to the land access and farming rights of the local herders (Maasi)
(Campbell, 1999). These types of restrictions experienced the same issues that are
experienced with drought influenced agricultural problems. Although the farmers were
ensured that the changes made would improve their overall situation, the goal set by the
authorities were not met and farmers were left with less opportunity and no visible
improvements (Campbell, 1999).

The countries that are more developed have access to a larger pool of resources that have
allowed them to develop techniques such as the climate and water management models
that have become a significant tool in drought response (Adger et al., 2003). Some
progress in these smaller regions have been made with resources being provided from
international organisations but these have been provided in the context of topics such as climate change or threats to biodiversity (Campbell, 1999). The aid and assistance packages that were offered were focussed around essential food supplies for the farmers and their families. Statistical surveys of farmers in the area showed that 65% of them received some type of basic food supplies during the drought event of 1994-1995 (Campbell, 1999). The contribution of official food aid was also a response strategy used within the Gambian province of Fulladu West, but has been steadily decreasing going into the 21st century (Jallow, 1996). A popular method used in Zimbabwe was the “food for work” programs that allowed those in need to work in order to receive regular ration packages (Kinsey et al., 1998). These were the primary form of relief to farmers with 98.6% of the household being studied receiving some form of food package during the 1991-1992 drought and 83% of those receiving food monthly for six months post drought (Kinsey et al., 1998).

Regions of Africa have been devastated by intensive and prolonged droughts and little or no rainy season. The governments within these areas have developed comparable policies, albeit at a much smaller scale. The federal responses in regions such as Gambia, and Zimbabwe are orientated around the feeding of the local farmers and their families. These are more humanitarian approaches and are part of an objective to protect self-providing farming communities instead of attempting to maintaining a commercial industry for economic reasons seen in more developed and market driven agricultural regions (Jallow, 1996, Kinsey et al., 1998).
2.2 Industry Responses to Drought

The relationship between industry and authorities is vital in the development of effective drought response and management strategies (Wilhite, 2005). The information needed to achieve accurate predictions of drought on short and long term production abilities is usually supplied by industry experts, as well as contracted crown research institutes. Studies carried out by the agricultural industry convey data that has been calculated about previous events to government agencies. The information gathered by research undertaken by Kiem (2013) and Horridge et al. (2005) serve as a framework to base policies and programs on in preparation for a drought event. A study that was carried out in on the effects of droughts on rural families in Australia by Edwards et al. (2009) provided statistics that indicated the huge strain of drought, not only on the business sector, but also on the personal aspects of their lives. It portrayed a grim picture where well-established farming families were suffering huge financial strain, resulting in some cases, selling up and moving (Edwards et al., 2009). Industry related businesses were also identified as having financial loss in regions of recurring drought. This type of information has been valuable to authorities and has provided an important link between them and the individual farmers.

A number of European countries have started to experience the impacts of drought events with a combination of agriculture intensification and changes in climatic patterns. Industry groups have pushed for research to increase the understanding of drought conditions, giving farmers the information needed to respond effectively. An example of drought response development is the real time forecasting system has been developed in order to predict long-range 30-day projections for soil moisture in the Consorzio Muzza basin, Italy. It is advances in forecasting systems that are providing farmers with crucial information, allowing them to make better decisions in managing irrigation and encouraging for overall improvement of on farm water consumption. For instance, a number of models and forecasting systems, such as the EPIC-PHASE introduced in 1997, are increasingly used in drought management (Ceppi et al., 2013). The increased interest in water resource management in the region also resulted in increased awareness of the implications of unsustainable water use ultimately improving the water management strategies used by farmers especially when regarding irrigation.
Although these actions are being taken, the data collected on surface water in the Murray Darling Basin between 2000 and 2009 gives an indication of the seriousness of the situation in the Murray-Darling, and presents the reality of what would need to be done to remedy the situation. With the total surface water in infrastructure dropping from 19 km$^3$ in November 2000 to its lowest point of 1.8 km$^3$ in April 2007 (Fig. 2.5), the necessity of dramatic measures to be taken immediately becomes more apparent.

Figure 2.5: Change in surface water storage in the infrastructure system (reservoirs, Lakes, weirs and channel storage) of the Murray Darling Basin. Source: Leblanc et al. (2009).

The various industries adversely affected by multiple drought events responded according to both the potential long term and short-term impacts of this emerging crisis. Government-industry relationships became more important to the effectiveness and efficiency of these responses (Leblanc et al., 2009). The combination of national scale authority and industry knowledge and experience seems to be necessary if the overall responses to these events are to be successful. There seems to be a lack of any major industry independent “crisis management” type schemes but the coordination with government agencies has proven to be highly beneficial (Botterill, 2003). An example of this can be found within the Murray Darling Basin, where both state and national government have coordinated with industry experts to develop more sustainable farming practices, especially around new irrigation technology and technique (Ballard et al., 2014).
Research and analysis seems to be the single most significant contribution of industry, with experts in fields such as economics, agriculture and statistics helping establish an overall awareness of event severity on specific areas. For example, during the 2002-2003 droughts in Australia, research was carried out to determine its impacts on the national agricultural industry. Southwest Queensland was estimated to have decreased gross production by 21%, while northwest New South Wales and Western Australia decreased by 18% and 17% respectively (Horridge et al., 2005). These findings allowed central and state governments to form the drought response packages such as those used in the USA as mentioned previously. The criteria for emergency loan programs included farm production to be $\geq 20\%$ in comparison to the previous average annual yields (Wilhite, 1986).

New Zealand has developed an influential industry assembly with agriculture being a significant contributor to the national economy, with emphasis on the dairy industry which is the world’s biggest single exporter of dairy products (Mairi, 2007). The importance of establishing sustainable practice in New Zealand agriculture has been highlighted with the increased intensive farming practices that have developed over the 21st century (MacLeod and Moller, 2006). To create a more approachable link between farmers and government, industry level group and organisations have been established to increase both farmer education and awareness of the importance of sustainable farming systems. With the increased emphasis of sustainability came the encouragement from both government and industry for farmers to improve their water resource management, especially with the widespread increase of irrigation occurring (DairyNZ, 2011). DairyNZ was established to support the farmers within the dairy industry.

The regions that are most prone to severe drought are also the largest dairy farming regions in the country, which are the Waikato and Canterbury. As intensive dairy farming has been considered one of the biggest threats to New Zealand’s sustainable water use, there have been resources poured into the industry to promote efficient water management at government, industry and farm level. DairyNZ has been providing numerous publications to farmers to support farmers and allow them to make informed decisions (DairyNZ, 2015). Examples for the publications provided by DairyNZ to New Zealand farmers include:

- “Smart Water use in the Farm Dairy”
- “Smart Water Use – Dollars and sense”
- “Smart Water Use – Short Form Action Plan”
- “DIY Irrigation Evaluation”
• “Guide to Good Irrigation”

Although New Zealand Industry organisations, such as DairyNZ, do not provide financial support, they provide information and advice to farmers that allow them to effectively manage their water resources more efficiently. The organisation strives to assist farmers to improve farmer awareness of the most efficient and cost effective ways to manage the on farm system. Numerous regional discussion groups take place and farmers are exposed, not only to what DairyNZ are providing, but to what other farmers are doing in the region.

2.3 Farmer Responses to Drought

There has been encouragement from governments towards farmers to accept and adapt as much as possible to the reality of an increased frequency of severe and potentially destructive droughts, ultimately increasing self-reliance (Botterill, 2003). This has been done by developing educational programs to inform farmers on how to better manage water resources (Wilhite, 2005), as well as the programs and policies that have been put in place in preparation for these events (Kiem, 2013). It is expected that farmers must take on their own measures to mitigate any possible impacts that are associated with drought. For instance, farmers in the Great Plains, USA have accepted this responsibility and have adopted numerous ways of attempting to reduce the loss that comes with drought. The most desirable farmer response is to have undergone preparation measures to mitigate any potential impacts of drought events. In addition to the measures, such as feed stockpiling and increasing financial resources available, there are farmers who have made significant investment into improving their water use through irrigation. Although many farmers within the USA established irrigation systems as a reality of the climate, many were not utilising the water efficiently (Zhang et al., 2015). This has introduced concern of the sustainability of existing water resources under the new pressures of irrigation. As depletion of the available resources continues and the reliability of consistent rainfall decrease, the significance of using water sustainably and efficiently is more important now than ever (Hornbeck and Keskin, 2014).

With less confidence in rainfall patterns over the agricultural areas of California, replacements for direct rainfall have resulted in farmers using groundwater. The Ogallala Aquifer is an example of a groundwater source in the great plains of the USA, where farmers have invested in infrastructure that allows them to rely on the aquifer as a primary water source (Hornbeck & Keskin, 2014). This has proven to be a temporary solution to
the water scarcity that the area has faced historically, and has been a recurring response in regions that have access to a resource of this nature. The main use of the water from the Ogallala aquifer has been for large-scale intensive irrigation for crops, such as wheat and corn, and it has been indicated that it is not a sustainable water resource for the intensity level of agriculture in the area (Hornback & Keskin, 2014).

Irrigation has been the solution that many farmers have chosen to compensate for an increasing lack of rainfall, and it has proven to temporarily incredibly beneficial to numerous farming practices, dramatically increasing production. The farmers in regions, such as the Murray Darling Basin, have reached a point where they can no longer extract water from the previous source, eventually putting them in the same position as the farmers who did not turn to irrigation (Ballard et al., 2014). This just confirms the concern that in many cases, intensive irrigation may not a viable and sustainable option. It has still become common practice in regions, such as New Zealand (North Otago), Australia (The Murray Darling Basin), United Kingdom and areas within the Mediterranean.

In addition to irrigation and developing groundwater resources, there have been other ways that farmers have prepared for drought events. Storage of supplement feed, saving money, and altering particular aspects of their practices are encouraged by policy makers (Wilhite, 1986). Farmers in South Africa’s agricultural regions have taken to diversifying their crops and focussing on improving their current resource management methods. These have been considered as long-term “survivorship” (Vincent et al., 2013). The herders in countries, such as Kenya and Gambia, have responded to the continuous drought conditions by diversifying crops to establish those that might be more tolerant (Jallow, 1996; Campbell, 1999). An example of this is the food source conversions that the locals of the Fulladu district have made from maize to millet. Millet production for personal production has increased from 47%-72% as it is more successful in drier conditions (Jallow, 1996).

Australia has some of the largest and most significant agricultural regions in the world. Areas, such as the Murray Darling Basin, produce between 20-30% of Australia’s total agricultural production (Leblanc et al., 2009). The residents that farm this area have depended on the flow of the Murray Darling River for irrigation as well as a source of ground water in the region. During the early 21st century, this highly productive area has been ravaged by a multiyear drought, which has resulted in a fraction of the mean rainfall in addition to record-breaking temperature (Leblanc et al., 2009). The farmers in this area have been subjected to irrigation restrictions, overall water restrictions, lack of pasture,
dramatic decreases in groundwater and a 23% decrease in the capacity of the Murray Darling River (Leblanc et al., 2009). Water also became a commodity in this region, often being worth more than the resulting production from its use. The awareness of the issue gave birth to “water sharing”, where farmers would sell their water allocations as they were more profitable (Ballard et al., 2014). Water sharing between the states of the Murray Darling basin has been implemented to improve the efficiency of the water available; a highly complex system has been put in place to do this as (Fig. 2.4). Factors such as these have pushed farmers in drought-stricken regions all over the world to take necessary and sometimes drastic measures to protect their lifestyle and income. Areas that have suffered through the most severe and prolonged droughts have had farmers who are not prepared to continue with the stress both financially and personally. It is becoming relatively common for farmers to sell both stock and land and move to urban areas (Edwards et al., 2009). This has occurred in parts of Australia, as well as countries within northern African such as Kenya and Gambia (Jallow, 1996; Campbell, 1999; Heathcote, 1988).

![Figure 2.6: The interstate water-sharing scheme established in the Murray Darling Basin. Source: Ballard et al. (2014).](image)

The size and place of the farmer’s establishment has an influence on their responses to drought. For example, the herders of the Kajaido district, Kenya and the Fulladu district, Gambia, tend to have very small scale, localised farming where the produce is only intended for sales to the local community or for personal/family consumption (Jallow,
The movement of livestock to distant water sources or the sales of higher maintenance animals has been a common occurrence in response to drought conditions in Kenya, with locals downsizing and prioritising the preservation of what water resources are available (Jallow, 1996).

### 2.4 Multi-level Response Analysis

One of the major components of the drought response strategies implemented in the case studies analysed so far, has been the communication between national/federal government, regional/state government, industry and the farmers. Sufficient communication between all parties has proven to be important in ensuring that all involved are aware of what strategies will be most effective, and what policies and support structures have been provided to promote effective and long term risk management to reduce regional vulnerability to drought (Wilhite, 2005; Kiem, 2013). The overarching policies for drought response such as the National Drought Policy 1992 are produced initially by national government and are then provided to state government who enforce the new policies and adapt them to the specific components that make up the individual regions (White and Karssies, 1999). The crucial component of the strategies that are being instigated is to increase the education of farmers to promote on farm risk management and farmer understanding of the National Drought Policy and all relevant legislation (White and Karssies, 1999).

In addition to the well-established multi-level management implemented in the Australian National Drought Policy, there are agricultural regions that are in the initial stages of drought response still highlighting the importance of multi-level involvement. The West Coast of New Zealand has drafted two plans to provide guidance to extreme natural events with some mention of drought. The Rural Business Continuity Plan 2012 published by Westland Milk Products (Fig. 2.7) and the West Coast Civil Defence Emergency Management Group Plan by the West Coast Regional Council, are two examples of how multi-level response is required when responding to not only drought but any natural disaster (Ingle et al., 2010; Pullen, 2012). The overall theme of the plans are generalised to any natural disaster, including drought and specifically consider the specific conditions that are present on the West Coast.
Figure 2.7: Flow chart describing the roles of various levels of local government and industry during the event of a natural disaster (including drought) on the West Coast of New Zealand. Source: Pullen (2012).

The Westland Milk Product Business Continuity Plan gives specific information regarding the dairy farms in the region and appoints relevant people to undertake the role of “rural responders” in various areas of the West Coast. West Coast Civil Defence Emergency Management Group Plan follows a similar theme, having various levels of authority playing a role in the overall response. The primary objective of these plans is to accelerate the accessibility of assistance and guidance under the following (Ingle et al., 2010; Pullen, 2012):

- Reaction
- Response
- Recovery

The importance of farmer response and co-operation holds just as much importance if not more, in ensuring that all actions taken by all levels are implemented effectively and in a timely manner to mitigated and manage the risks (Ingle et al., 2010; Pullen, 2012). The West Coast Civil Defence Emergency Management Group Plan is based on a framework that is implemented as a national response (Fig. 2.8) but the West Coast Plan has incorporated the geographic and climatic conditions present on the West Coast.
2.5 Crisis management versus Proactive Response to drought

A number of drought events provide multiple examples of how farmers, industry and authority respond to the adverse effects of drought on agriculture. The two major themes of responses are reactive and proactive, which are explained in detail below.

Crisis management responses were those that occurred in the later stages of the event or after the event had occurred. The concept of reactive was described by Wilhite (1986) to be “The implementation of hastily prepared assessment and response procedures that may lead to ineffective, poorly co-ordinated and untimely response.” This was a reoccurring pattern with many of the case studies such as the response to the early droughts of the 1930s in both the Great Plains and the Murray Darling Basin (Wilhite, 1986; White et al., 2001; Wilhite, 2005) that involved crisis management responses not achieving the appropriate assessment and resulting actions to carry out a comprehensive response strategy. It was also highlighted that many of these actions would be undertaken during a highly emotive time where the judgment of all involved may be impaired ultimately adversely impacting the decision making processes at all levels (Kiem, 2013). The actions that fell into this category were the “drought relief” packages given by government in most of the cases analysed (Wilhite et al., 2000; Kiem, 2013). Government intervention of this kind played a huge role in shaping policy, especially in the early drought response research where there was limited experience in drought response (Wilhite, 1986). The responses by
the USA government incorporated extensive relief strategies in the earlier drought policies, especially during the droughts of the 1930s and 1970s with loan packages and cash injections into the most impacted industries (Wilhite, 1982). The earlier response strategies carried out by Australian farmers impacted by extensive drought were similar but begun to adopt more preventative measures especially when drafting the National Drought Policy in 1992 (Wilhite, 2005).

Proactive responses were those that were implemented to prepare for the event, or to eliminate the risk associated with drought before farmers felt any of the associated impacts (Botterill, 2003). The preventative, preparation response approach appeared to increase with increased occurrence of drought and the associated experience in drought response and management. Many of the countries starting to experience have the advantage of incorporating what was learned from the mistakes of regions that have been managing drought since the early 1900s such as California, USA and the southern states of Australia (NSW, VIC and SA). A defining document for preventive and proactive incorporation in drought response and management was the Australian National Drought Policy drafted in 1992, which based its policies and strategies on risk assessment and the objective of decreasing farmers’ vulnerability to the impacts of drought. The addition of the National Drought Policy in Australia signalled government and state coordination in making their farmers more prepared for drought, by improving water management and infrastructure, ultimately being more efficient and reducing overall consumption of water (Kiem, 2013; Ballard et al., 2014).

### 2.6 Research Agenda

The overall drought response pattern of those involved with agriculture is beginning to shift into a more proactive and adaptive approach (Wilhite, 2005). The importance of a multi-level response incorporating government, industry and farmers is important to ensure that the actions taken are based on consistent and informed decision making processes. The research that has been based around drought response is compelling and does not leave many obvious sizable gaps for future research. The majority of previous research, however, has been focussed on arid areas that experience frequent drought events such as North Africa, Australia and Northern America. The concentration of governments on the more intensive agricultural regions have overshadowed the impacts of drought on the
smaller rural communities that have begun to experience drought induced stress associated with changing climatic conditions. A potential gap in research to date, are areas that have only recently started to experience drought, or regions that may experience episodic droughts despite being situated in a high rainfall climate. The examples described in chapter have given an indication of how drought regions all over the world have responded to drought and what strengths and weaknesses each response had. Investigating the history of drought response and making comparisons between historical actions and recent strategies has allowed for analysis of the developments that have been made. As technology and increased experience in drought management is incorporated into the roles of national/federal government, local/state government, industry and farmers, the effectiveness of the response, as portrayed by the case studies, has improved.

The case studies that dominate the current pool of research have been the response of rural communities in drought prone or arid regions. How do regions that do not have a history of drought but have recently experienced drought compare? Are the response strategies similar or does the added dynamic of a high annual rainfall require further consideration. As climatic uncertainty increases with the onset of climate change, will areas of a high annual rainfall need to consider the potential risk of drought, or do the costs associated with the additional risk management measures outweigh the benefits of drought preparation?

Questions such as these are important when considering the potential impacts on a rural community such as the Grey Valley on the West Coast of New Zealand which experiences high rainfall, but has also recently experienced drought. What actions have or have not been taken by farmers and what government and industry involvement has occurred. Ultimately, what are the responses of Dairy Farmers, Industry and Local Government to Drought Events in the Grey Valley, West Coast?
3 Research Context: Regional Geography of the West Coast and Grey Valley

3.1 Study Locale, Grey Valley, West Coast

The West Coast is a rurally dominant region with small townships supported by predominantly primary industry such as agriculture, mining, fishing and forestry (Wilson, 2013). These industries have played an important role in the development of the regional economy and the distribution of the population. The establishment of urban areas has been determined by the locations of major agricultural areas or mines. The three major townships Hokitika, Greymouth and Westport are situated on the coast and either presently have operating ports or have done in the past. The key use of these ports in the past was for the transport of resources such as timber, coal and agricultural products and eventually also incorporating a fisheries industry. The West Coast has always been renowned for its wild weather, rugged landscape and spectacular scenery for tourism.

The construction of the Lewis and Arthurs Passes in 1860 and 1864, respectively, through to the eastern side of the island became the primary method for transporting goods, and made the region far more accessible (Stephen-Gair, 1966; Atkinson et al., 2014). Modern transport of goods is almost entirely through these mountain passes, which have limited the use of the existing ports to primarily fisheries. The significance of mining in the region gradually decreased giving way for the boom in agriculture, which was initially sheep and dry stock (Source: NZ Stats Table Code 7423). Many farmers converted to dairy in the late 1800s with the increased global demand for dairy products, and the establishment of the Westland Milk Products factory in 1937 (Fig. 3.1).
Since the formation of the company, the number of dairy herds on the West coast increased to 376, with dairy becoming the fastest growing industry on the West Coast with a 19.7% increase between 2002 and 2012 (Wilson, 2013). Dairy has become a significant industry on the West Coast providing direct employment on farm, and indirect employment in the form of local contractors. The maintenance and development of the dairy industry on the West Coast is important and any collapse would dramatically impact numerous communities, primarily resulting in a significant drop in employment. The impact of the 2013 drought event highlighted the vulnerability of the West Coast dairy industry to drought events and the impact an increase in frequency and severity would have in multiple areas. Regions prone to recurring droughts have been well studied and provide a considerable level of understanding of response strategies to drought, as described in Chapter 2. Although drought research in dryland agricultural regions is abundant, there is a lack of research on the impacts of drought on areas with a high annual rainfall, which are still subject to drought events, but are not present in the current drought management strategies. With the uncertainties that are surrounding the current changes occurring in the global climate, drought events in high rainfall regions need more attention. Investigation into drought response processes needs to focus on strategy comparisons and analysis of effectiveness in mitigating the adverse effects of drought events on agriculture. A common misunderstanding in studies regarding drought is the difference between drought and water scarcity and how these are related. Drought is a naturally occurring event caused by climate variation, whereas ‘water scarcity’ is the unsustainable use of water resources from...
rivers, aquifers and other available resources (Van Loon and Van Lanen, 2012; Van Lanen et al., 2013).

Over the last two decades strong milk solid prices have favoured investment in water storage and irrigation, and have allowed the dairy industry to become established in regions of New Zealand with a low annual rainfall such as Canterbury and Otago. Figures sourced from Statistics New Zealand indicate that in 2007 dairy farming had a considerably larger area of irrigated land (234,619 ha) than any other agricultural industry on a national level. As the total national irrigated area is 619,293 ha, the dairy industry makes up over a third of the total irrigated land in New Zealand. Statistics gathered in 2012 showed that the West Coast had the smallest irrigated land area with only 2,333 ha out of a national total of 721,740 (Statistics NZ, 2012).

The need to preserve and ensure the long-term establishment of agriculture with emphasis on dairy is an important step, not only for the good of the industry, but also for the local community (Conradson and Pawson, 2009). Agriculture has been facing major issues both internationally and in New Zealand with the struggle to mitigate water pollution and preserve local biodiversity, but one particular issue that has proven to be a challenge is increased pressures agricultural practices are putting on water resources (Bernot et al., 2010). With the added concern of changes in global rainfall patterns and the increased occurrence of drought events in major agricultural regions, the persistence of water demanding farming practices are of significant concern to local economies and sustaining rural livelihoods.

Pressures associated with climate change related variability in weather patterns are already being felt in farming communities and have sparked a range of different response strategies dependent on the knowledge and resource available. There has been a prominent divide between proactive and reactive responses and these themes have occurred in various agricultural regions (Kaine and Cowan, 2011). The terms proactive and reactive in this context refer to the nature of actions taken to attempt to decrease the adverse effects of a drought event, and case studies have provided an insight into the various types of response strategies that fall into these two themes. Although there have been many improvements and is now a better understanding of drought response, there is still very much a recurring categorization as either proactive or reactive (Wilhite, 1983; Jallow, 1996; Kiem, 2013;
Vincent et al., 2013). The differences between the two response types are highly dependent on the timing of the actions taken and the desired outcome of that action.

Although droughts are only thought of as being an issue in arid areas, these events are becoming more frequent in moderate to high rainfall regions. The West Coast of the South Island, in New Zealand, receives an annual average of 4500 mm and would not be thought of as being at risk of drought but in the summer of 2013, Reefton a settlement situated in close proximity recorded 45% (80 mm) of the average rainfall for February and 24% (39 mm) of the average rainfall for March (Griffiths and Chappell, 2013; Tait et al., 2013). Reefton also experienced the highest mean temperature (12.6°C) on record for February. The local township of Greymouth recorded the highest number of sunshine hours on record, as well as the third lowest rainfall for February, ultimately displaying the regional effects of sustained high sunshine and low rainfall across the Grey Valley.

Other regions within New Zealand, however, such as North Otago, Canterbury and Northland regularly experience drought conditions, and have regional drought response plans, tailored to the specific needs and conditions of each specific region in addition to on farm responses, such as water storage and irrigation. A large portion of the country felt the severity of the 2013 drought event and many agricultural regions suffered huge losses, both financially, and in regard to the stability and future persistence of certain agricultural practices. There have been numerous plans and response strategies put in place to deal with these events on a regional scale but these tend to be in most part missing the specific drought response component on the West Coast. Some examples of published plans include:

- Drought Guide -Definition, recognition and assistance measures, February 2009: MAF;
- Response and Recovery Plan 2011: Rural Support Trust Northland;

These plans all lack the specific impact of a drought on the distinctive circumstances that the West Coast faces both physically and strategically. The landscape and climate that is managed by West Coast farmers (Fig. 3.2) differs dramatically to the other major
agricultural regions in New Zealand, making it ineffective to attempt to apply another regions plan during an event. The response plans that are in place for the West Coast, such as the Rural Business Continuity Plan 2013-2014 by Westland Milk Products, are mostly for wet weather events, or are based on generalized response strategies that consider the specific challenge associated with drought. Overall there are very little, if any drought response plans in place specifically for the West Coast, giving farmers very little guidelines or support during or after an event.

The West Coast is one of the few regions that has not implemented a plan specifically targeting drought events and due to the small number of past drought events, a lack of response strategy proved to be a complication during the dry period between January and March 2013 (Porteous and Mullan, 2013). Although the West Coast is not an area known to be prone to drought conditions, it is becoming clear that a drought response plan is still necessary and would certainly be beneficial to the region. In order to implement such a plan, it is important to have an indication of both the awareness and attitude the farmers, industry and both local and national government have towards the issue at a local scale. The farming community of the Grey Valley will be ideal for such research as there is a range of small to large scale farms that are mostly dairy.

![Image of land converted into dairy pasture in Grey Valley, West Coast](image-url)

*Figure 3.2: Example of land converted into dairy pasture within the Grey Valley, West Coast Source: VCS Environmental.*
The site chosen for this project is the Grey Valley. The rationale for this choice of study site is that the area comprises of mostly dairy farms and sits on a river plain with a soil profile with very high drainage and low water retention. This meant that during the drought event of 2013, the farmers of the Grey Valley were some of the worst effected in the region and suffered a soil moisture deficit of $> 110$ mm (Revell and Macara, 2014; Porteous and Mullan, 2013). By interviewing a group of farmers representing different property sizes, farming styles, locations and stock rates, the objective is to identify an overall response trend. The information collected and analysed in this study would give the farmers, industry and local government an indication of the attitudes and awareness of the local agricultural community to the overall point of view regarding drought. This could potentially direct the necessary interest and resources to issues that are highlighted, ultimately increasing preparedness in the case of a future drought scenario.

Studies such as these could potentially become an important source as farmers, industry and local authority take action to ensure that the dairy industry is more prepared and can manage drought without bring adversely impacted. Increasing the awareness of the impact of these events on the smaller rural communities in New Zealand is important, hopefully ensuring they are not overlooked during drought, and encouraging increased support from national government. This is especially important to a region such as the West Coast, whose community and economy relies heavily on the dairy industry’s success.

### 3.2 Study Site – Grey Valley

The West Coast of the South Island is a mixture of temperate rainforest, farmland and small townships. It is bound between the coast and the Southern Alps and is drained by numerous major waterways including the Hokitika, Arahura, Taramakau and Grey Rivers. The West Coast has a mixture of both flat and mountainous terrain, with most of the plains being associated with river systems within formerly glaciated valleys. The West Coast is one of the geographically largest regions in New Zealand but only has approximately 32,000 residents (Statistics NZ, 2013). The primary industries of the region since the early 1900s have included coal/gold mining, fisheries and more recently, tourism and dairy farming. The main settlements of the region are highly dependent on these industries to maintain the regional economy and community. The development of these industries has resulted in major modification in the landscape, with areas of native rainforest being
cleared for pasture and infrastructure such as milking sheds and, in the Grey Valley in particular, irrigation systems. Major concerns about the future of the West Coast Economy has been highlighted with collapse of the coal industry, and the various challenges faced by other primary industries such as dairy and gold mining with both facing drops in global commodity prices over the last 5 years (Fig 3.3, 3.4).

**Figure 3.3**: Global gold prices (NZD) between 2013 and 2015. Source: Gold Price Pty LTD (2015).

**Figure 3.4**: Pay-out prices for Whole milk prices between 2010 and 2015. Source: DairyNZ Statistics.
The Grey Valley is located about 15 km north of Greymouth and follows the Grey River. The area is protected by the Paparoa Ranges on the west side and is adjacent to alluvial plains on the east followed by the rolling foothills of the Southern Alps (Fig. 3.5). The average rainfall ranges between 4000 - 5000 mm and the annual temperature mean fluctuates between 11-12°C (Revell and Macara, 2014). Conditions are relatively consistent throughout the year with no obvious dry or wet season and the wind patterns are mostly dominated by the westerly flow but south-westerlies and nor-westerlies are also common (Hessell, 1982).

![Figure 3.5: Study Location of Greymouth and the Grey River on the West Coast of New Zealand. The Grey Valley, which is the focus of this project runs from Greymouth in a north-easterly direction along the trunk river towards Reefton.](image)

Agricultural pasture dominates the lowland valley area, with mostly dairy farms but also a small portion of cattle, sheep and deer farms. Although the fluvial soil characteristics have allowed for the establishment of intensive dairy farming (Fig. 3.6), the use of industry appropriate fertilizer is common practice to maintain steady and consistent pasture growth. The soil profile also has a low water retention and high drainage (Fig. 3.7, Fig. 3.8).
The topography of the Grey Valley consists of relatively flat plains adjacent to the Grey River, surrounded by mountainous ranges (Fig. 3.6).

Figure 3.6: Aerial image of the Grey River Valley. Source: Bing (2015).

Figure 3.7: Soils types of the Grey Catchment Source: Landcare Research (2010).
The Grey Valley contains approximately 64 dairy farms ranging in plot and herd sizes with various levels of infrastructure and farming technique. A number of the farms have large scale irrigation systems and rely on these systems to promote consistent year round pasture growth. Others devote land to producing a variety of supplementary feed types including silage, lucern and turnips. The farming intensity also ranges throughout the Grey Valley with some farms being closer to a hobby and some being the primary source of income to the farmer. The catchment was categorized into three sub sections – the lower, mid and upper Grey Valley (Fig. 3.9):

- Lower Grey Valley: Greymouth to Stillwater
- Central Grey Valley: Stillwater Totara Flat
- Upper Grey Valley: Totara Flat to Mawheraiti
Figure 3.9: Map of the discrete segments of the Grey River Valley used to partition the respondents.
4 Methodology & Research Questions

The qualitative approach used in this study has common use in social research due to its ability to recognise the emotional and human aspect of the information, in addition to the evidence that is obtained from the questions in the interview. The design and structure of these questions plays a really important role in allowing the interviewing process to flow naturally and allow the informant to feel relaxed, increasing trust between the interviewer and the informant ultimately improving the quality of the information receive (Knox and Burk, 2009). Although quantitative research would have provided more substantial data for statistical analysis, undergoing a qualitative study allowed for extra information from the farmers to make up an important part of the overall outcome of the research. The experience of individual informants resulted in a far deeper analysis of the challenges associated with drought, highlighting how the informants involved were affected at a personal level instead of just analysing the business aspect. The qualitative approach allowed for the informants to be perceived as an individual person with different values and experiences then just another agricultural statistic. The gathering of information this way allows for any local and West Coast specific experience to play a role in the management of drought, and how farming on the West Coast results in the specific response strategies that the Grey Valley dairy farmers use during the 2013 event and what they may use in the future. The techniques of this study were an effective and informative approach and the interviewing process allowed the researchers involved to engage in the issues experienced by the farmers at a much more personal level (Kitchin and Tate, 2000). This assisted in the interpretation of the information collected and how significant it is to the overall research questions of this study (Seidman, 2013). The flexibility associated with qualitative analysis allowed for previously overlooked viewpoints of farmers to be suggested and explored. By considering this additional information, the conclusions made could potentially be far more profound and justified by the local knowledge provided by the individuals involved. Overall, this research will be an important addition to the awareness of this issue to both West Coast agriculture and the wider scientific community.

Specifically, this research addresses:

- What were the impacts of drought on farmers considering financials, stock welfare and ability to farm?
- Did the severity of previous drought events have an accumulative effect on farms within the Grey Valley?
- What strategies do farmers put in place in to mitigate the adverse effects of a drought event in the Grey Valley?
- What strategies does the industry put in place to mitigate the adverse effects of a drought event in the Grey Valley?
- What strategies do local and national governments put in place in to mitigate the adverse effects of a drought in the Grey Valley?

4.1 Data Collection Methods

The information gathered by this study was done so using a semi-structured interview technique. The rationale for this choice was that it allowed an easy flow of a conversation while still obtaining the information needed to answer the questions outlined in the questionnaire (Kitchin and Tate, 2000). This has been confirmed to be an effective way to extract information that might not be directly related to the question but could potentially be valuable to the study and could in fact introduce a point that was not previously considered that might benefit the outcome of the research. The purpose of including both industry and local authority members is to establish the policies or lack of, that are currently in place to support West Coast dairy farms, and what local government are proposing to do in order to attempt to mitigate the impacts of drought events on the West Coast dairy industry. Identifying any gaps in these policies and comparing and contrasting them with policies designed for other regions will hopefully give an indication of whether the current West Coast drought response policies are adequate and whether more attention needs to be directed to improvements.

The purpose of the owners, share milkers and farm managers being targeted was to utilize their knowledge of both the practical and financial implications involved with both previous drought events and future responses to droughts. It is considered that more junior staff may lack the knowledge or experience required to effectively participate in the study. Farmers were initially contacted to request participation in the study and a previously planned time was confirmed, preventing pressure for the interviewee. Information for this study will only be that collected during the interview, ensuring it is the interviewee who is providing the information. This approach could potentially result in far more detailed and
well thought out answers to the questions resulting in valuable and relevant information (Kitchin & Tate, 2000).

4.1.1 Interviews

4.1.1.1 Farmers

Farmers operating dairy farms situated on both sides of the Grey River in the Grey Valley between Greymouth and Mawheraiti were interviewed during the period from December 2014 to July 2014. The sampling was completed using the purposive sampling technique where farmers were chosen to represent this area according to herd/farm size and to represent the lower, mid and upper of the sections of the Grey Valley (refer to Table 4.1). The sampling methods were subject to the number of farmers available and willing to participate. Each section was represented by farms of various farm sizes, which will be chosen according to the herd size and number of hectares the farm covers. The range of farmers will also be considered, with age of the owner and the time the farm has been established being included.

Table 4.1: Farming Interview informant data.

<table>
<thead>
<tr>
<th>Informant ID</th>
<th>Herd size 2013/14</th>
<th>Farm Size (ha)</th>
<th>Location</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>farmer informant 1</td>
<td>360</td>
<td>260</td>
<td>lower</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 2</td>
<td>820</td>
<td>482</td>
<td>mid</td>
<td>N</td>
</tr>
<tr>
<td>farmer informant 3</td>
<td>360</td>
<td>206</td>
<td>lower</td>
<td>N</td>
</tr>
<tr>
<td>farmer informant 4</td>
<td>490</td>
<td>202</td>
<td>lower</td>
<td>N</td>
</tr>
<tr>
<td>farmer informant 5</td>
<td>685</td>
<td>500</td>
<td>mid</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 6</td>
<td>1000</td>
<td>672</td>
<td>mid</td>
<td>N</td>
</tr>
<tr>
<td>farmer informant 7</td>
<td>830</td>
<td>485</td>
<td>upper</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 8</td>
<td>720</td>
<td>350</td>
<td>lower</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 9</td>
<td>600</td>
<td>248</td>
<td>lower</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 10</td>
<td>1470</td>
<td>440</td>
<td>mid</td>
<td>Y</td>
</tr>
<tr>
<td>farmer informant 11</td>
<td>no data</td>
<td>206</td>
<td>upper</td>
<td>N</td>
</tr>
</tbody>
</table>
The interviewee from each farm was visited once, for introduction purposes and to be given the questions and undergo the final interview. The visit consisted of an introduction to the interviewer, the questions and some information regarding the project and how the interview would work, including the aspect of recording the interview. The member of the farm that was interviewed was determined to be the informant that could provide the most appropriate information, ideally the owner, or the farm manager/share milker. Measures were taken to ensure that the interviews and the use of the information provided complied with the regulations outlined by the University of Otago human ethics committee. Each interview was recorded for scribing purposes and consent from each interviewee ensured. The information gathered at each interview was only used for the purposes of the project and not revealed to any other party, without the explicit permission of the interviewee and owner of each individual farm. The interviewing technique that was used was a semi-structured open-ended interview conducted face to face with 11 farmers, two industry Informants and one local authority Informant.

4.1.1.2 Industry members

The information needed from the local industry members was obtained in a similar interviewing approach as that put in place for the farmers. Those involved were given the same questions that were given to the farmers and any interview was recorded with the same precautions taken to ensure consent. The industry organizations interviewed were Westland Milk Products, Dairy NZ, and Think Water (Greymouth). These provided a range of perspectives that came with their specialty positions with Westland Milk Products being a consumer of the farmer’s products, Think Water being a business supplying farmers with infrastructure such as irrigation, and DairyNZ who provide statistics and ongoing support to both farmers and industry.

4.1.1.3 Local Authority

Regional policy was analysed in addition to the information gathered about the support systems that are currently in place to assist farmers in drought stricken agricultural practices both nationally and specific to the West Coast. An interview was also carried out with a local member of the West Coast Regional Council.
4.1.2 Data Analysis

The data collected in the interviews was recorded and transcribed to allow for later analysis. The analysis of the information gathered during the interviews and further investigation allowed categorising farmers depending on the size of their farms, herds and their location. Direct quotes by the individual farmers were interpreted and were utilised to help paint a picture about how the farmers were responding individually, and then how the farming community was responding as an industry. The influential factors that impacted responses such as topography, soils, climate and the dairy pay-out were used to attempt to understand why individual farmers responded in a particular manner. Once the information about these influential factors were dismantled and understood independently, they were reintroduced into the management strategies chosen by farmers, response themes and became obvious, and an overall responsive approach could be identified.

4.2 Limitations/Challenges

There were a number of limitations and challenges involved with this project, mostly around the availability and willingness of farmers to participate. This was the single most significant obstacle with the final number of interviews undergone being less than anticipated. Finding the appropriate time to carry out the interviews with many farmers was challenging as they had limited additional time especially during the milking and calving seasons. Much of the Grey Valley, being a rural area, does not have cell phone reception and many of the farmer’s contact details were not available. Being unable to contact the farmers via telephone or email did become an issue as arriving onsite without warning was not appropriate. Many of the farmers approached, including a few who were involved, did not feel the project was not applicable to them as they did not consider themselves to have been affected by the 2013 event.

Some of the farmers were also hesitant to elaborate on the information they gave when answering the questions, leaving room for extensive interpretation of the information they did provide. The questions could have presented issues and needed to be communicated in such a way that the farmers did not feel interrogated or hounded. Approaching the farmers as an outsider could also could have resulted in them being closed off and not as willing to participate at a full and open manner. Being a local from the West Coast provided common ground during the questioning and ensuring those being interviewed were aware that the
study may benefit the region was an approach that increased the level of participation during the discussions. A challenge that arose during the interviews was the perception from the farmer about what was going to be done with the information gathered from them.

4.3 Conclusion

The methods used in gathering the information needed was effective in answering the research questions and allowing for analysis in the results in chapter 4. The open ended questioning and the semi structured interview approach encouraged additional information from farmers that may not have been considered in the initial research design and as a result gave the study far more depth and dimension. The information received from each informant paired with the numeric information gathered from sources such as DairyNZ, Land Information New Zealand, NIWA and Landcare Research provided values that either confirmed the information from informants or highlighted factual conflicts that gave way for interesting and multi-dimensional analysis and interpretation of the information.
5 Results & Implications

Chapter 5 describes the findings and themes that were identified from the investigation into the response strategies of the Grey Valley Farmers, Industry and local government. Sections 5.1 highlight the environmental factors (topography, soil and climate) that influence response while Section 5.2 describes the evidence gathered from the interviews with dairy farmers and 5.3 describes the findings regarding industry and management factors influencing response.

Drought is becoming a widespread issue in global agricultural industries. With climate change being increasingly accepted, the continuing occurrence of severe drought events in renowned farming regions is an alarming reality for global agriculture. Practical and cost efficient response strategies are what farmers in the effected regions are relying on to maintain a viable and financially resilient farming system during drought. The awareness of drought-related impacts on these industries typically surrounds large intensive farming regions, with those who are smaller and more remote often being overlooked. Locations such as California and the Murray Darling Basin have been emphasized in global media, and have set the scene for the implications of drought on agriculture and the on-going future challenges being faced by farming regions all over the world. These are case studies at the extreme end of the spectrum, with the very existence of future agriculture being questioned in some cases. The reliance of local, domestic and international markets on the production capability of an agricultural region prompts action to prevent or mitigate the adverse effects of drought events of this scale on farmers and industry that relate so heavily on the climate to effectively produce their products.

When discussing the topic of drought, the larger more significant agricultural regions receive far more exposure than the smaller less known agricultural regions. An example of this is the Grey Valley, located on the West Coast of the South Island, New Zealand. The Grey Valley region has been dominated by agriculture and mining with the primary industry being sheep and dry stock farming for meat products, as the dairy industry grew, the number of beef cows and sheep decreased with dry stock farms being converted into dairy. The dairy industry on the West Coast increased in both cow numbers and number of effective hectares (Fig. 5.1, 5.2).
Figure 5.1: Number of Dairy cows, beef cows and sheep between 1994 and 2013. Source: NZ Stats Table Code 7423.

Figure 5.2: Number of Dairy Herds on the West Coast, New Zealand between 2010/11 – 2014/15. Source: DairyNZ – New Zealand Dairy Statistics.

Although herd numbers on the West Coast varied between 2010 and 2015, the overall trend has indicated a growth of four new dairy herds being established on the West Coast. This, in addition to the growth of existing farms, has resulted in an overall increase in the number of hectares under effective production (Fig. 5.3) showing a total increase in hectares between 2010 and 2015 of 3,906 ha. As a response to the increases in both herds and hectares, the number of dairy cow on the West Coast has increased by 10,316 between 2010 and 2015 (Fig. 5.4).
The Grey Valley, although small in area, is part of the Grey District, one of three major dairy districts on the West Coast alongside South Westland and Buller. The characteristics of dairy activity in the Grey Valley, although not as significant as the overall West Coast numbers, have also been showing an overall increase between 2010 and 2015 (Table 5.1).
Table 5.1: Dairy statistics for the Grey Valley, West Coast between 2010/11 – 2014/15.
Source: DairyNZ: New Zealand dairy statistics.

<table>
<thead>
<tr>
<th></th>
<th>2010/11</th>
<th>2011/12</th>
<th>2012/13</th>
<th>2013/14</th>
<th>2014/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Herds</td>
<td>86</td>
<td>86</td>
<td>85</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>No. of Cows</td>
<td>39,977</td>
<td>39,642</td>
<td>40,321</td>
<td>40,950</td>
<td>41,901</td>
</tr>
<tr>
<td>Total effective hectares</td>
<td>17,588</td>
<td>17,584</td>
<td>17,798</td>
<td>18,331</td>
<td>18,411</td>
</tr>
</tbody>
</table>

The Grey Valley has a highly variable soil profile with a topography that ranges from gravel river terraces of the Grey River through to the foothills of the Paparoa Ranges (Fig. 3.7, Fig. 3.8). The inconsistencies present on farm such as pockets of dense vegetation and the high number of on farm waterways and trenches do need to be taken into consideration by farmers when considering response strategies. For example, to install a series of pivot irrigators, farmers need to have a large section of pasture without any major obstacles. Many of the natural characteristics of farms can be altered if a resource consent is granted, but this increase expenses and may be discouraging to farmers during the decision making process, especially for irrigation. Due to regional regulations, these areas of native forest cannot be removed, and therefore farmers must work around them if they cannot obtain resource consent for removal.

The development of West Coast dairying practices and increasing conversion of land was unexpected by many due to the unfavourable conditions concerning the soil properties, inconsistent topography and climate. The area has an average annual rainfall of approximately 3000 mm (WCRC, 2011) presenting dairy farmers with a number of challenges concerning flooding and pasture growth. Many farmers struggled with the boggy and sodden soils that are characteristics of much of the West Coast and contributed to by the consistent high rainfall. Over the years, the dairy farmers of the Grey Valley developed adaptations to manage the wet conditions with methods such as pasture flipping and humping and hollowing. With the addition of new and improved pasture management, the farmers improved their ability to produce sufficient milk product to maintain a sustainable farming unit. Although managing wet conditions is a highly significant component of farming on the West Coast, the emphasis on managing wet conditions has resulted in farmers overlooking the possibility of dry conditions being a significant issue. The prioritisation of many dairy farmers, such as those in the Grey Valley to adapt their properties to the primarily wet climate did mean that they became vulnerable to the
implications of drought events on their farming system. The climatic conditions and topography has impacted production of farmers on the West Coast not allowing it to be as high as other farming regions such as Canterbury. The region has, however, been able to maintain a comfortable stocking rate and production rate per cow (Table 5.2 and 5.3).

Table 5.2: Average regional Herd Size. DairyNZ: New Zealand dairy statistics.

<table>
<thead>
<tr>
<th>Region</th>
<th>2011/12</th>
<th>2012/13</th>
<th>2013/14</th>
<th>Regional Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canterbury</td>
<td>398.5</td>
<td>380</td>
<td>392</td>
<td>390.2</td>
</tr>
<tr>
<td>West Coast</td>
<td>338</td>
<td>332</td>
<td>359</td>
<td>343.0</td>
</tr>
<tr>
<td>Otago</td>
<td>381</td>
<td>367</td>
<td>381</td>
<td>376.3</td>
</tr>
</tbody>
</table>

Table 5.3: Average Milk Solids per cow (kg).

<table>
<thead>
<tr>
<th>Region</th>
<th>2011/12</th>
<th>2012/13</th>
<th>2013/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canterbury</td>
<td>695</td>
<td>726</td>
<td>806</td>
</tr>
<tr>
<td>West Coast</td>
<td>402</td>
<td>408</td>
<td>404</td>
</tr>
<tr>
<td>Otago</td>
<td>587</td>
<td>617</td>
<td>607</td>
</tr>
</tbody>
</table>

Although the average amount of milk solids per cow and herd size is less than other regions (Tables 5.2 and 5.3), the viability of dairy farming on the West Coast is the amount of financial resources needed to purchase and develop a dairy unit. The West Coast has one of the lowest sale figures per hectare than any other region in New Zealand with the average value for a hectare being $26,000 – $28,000. As the national average price per hectare being $31,500 along with Canterbury being similar at $31,800, the West Coast stands out as a less expensive region to purchase a dairy unit. The less financial pressure involved with purchasing land provides the farmers more leverage to develop the farm and allows West Coast farmers to potentially purchase larger land parcels ultimately giving them the option of a higher stocking rate.

As the issue of global climate change becomes commonplace and the changes such as weather extremities and longer dry periods being observed become more frequent, the
adaptive behaviours of farmers in both large and small scale agricultural regions are having to change to manage new conditions (Iglesias and Garrote, 2015). In 2013, the Grey Valley suffered a severe drought event in many years, impacting the dairy farming community greatly. The event was present in numerous regions around New Zealand with higher than normal temperatures, and record breaking low rainfall. The majority of the West Coast, including parts of the Grey Valley, suffered from soil moisture deficits between 110 mm and 130 mm during the event that took place between January and March of 2013 (Turner and Chappell, 2013). Although drought events had occurred in the area previously, the intensity and duration of this was unanticipated, leaving both farmers and industry unprepared and particularly vulnerable to the adverse effects associated with drought.

5.1 Environmental Influences on Drought Response

Inconsistent topography, abruptly changing soil profiles and climatic conditions were physical challenges faced by the farmers of the Grey Valley. These were factors that were relevant when developing not only the everyday farming system but also the decisions made during unfavourable conditions, such as those experienced during drought. The information gathered from those interviewed showed a mixture of adaptive strategies that revolved around modifying the environment to suit the farming practice’s needs. The variation shown by the Grey Valley dairy farmers represented the differences in both the physical differences of the area and the decision making of each farmer involved. The distinctive combination of these factors resulted in the individual response strategies of each farmer, with some being highly effective and some being inadequate to mitigate the adverse effects of drought.

5.1.1 Topography and Soil Characteristics

The topography and soil characteristics had a profound impact in the response of the farmers, particularly when considering the option of irrigation. Challenges associated with the profile of the farmland and how it limited the ability to irrigate the property was discussed with a number of the farmers. The ideal topography for irrigation, such as a pivot, would be expansive, flat and symmetrical. Many of the farms in the Grey Valley vary in shape and size, with some being tucked into narrow valleys and along the foot of the Paparoa ranges. The below statement was given by a farmer who converted his property
in 2000 through a narrow valley and has had to adapt his farming system according to the farm profile.

“My farm is long and narrow it would be difficult to irrigate.” - Farmer informant 6

Discussion of the details of farm profile or shape and the implications that it had on the options that were viable to establish protection against drought became a reoccurring topic, where the response strategies needed to suit the physical properties of each individual property. This was a common theme among the farmer’s interviewed was that they tailored their responses to be as effective as possible for their properties instead of conforming to the trends of other farmers in the area. Once again this seemed to be an approach taken by farmers to adapt to the restrictions of the Grey Valley instead of establishing a standardized farming system that would be the prominent in intensive dairy regions such as Canterbury and Otago. The West Coast landscape has presented these challenges to farmers, which tend to be reasonably adaptive and resilient.

The physical nature of many Grey Valley farms was an important factor when considering drought response, with many explaining how the soil characteristics have a huge influence on decisions not to irrigate. With 55% of the interviewed farmers irrigating, the understanding of the significance of soil was fairly extensive, especially among the farmers who had farmed a single property for a long period of time. Even those who had been new to their current property, the available data and technology had allowed them to become familiar with the soil structures of their property, giving them the tools to respond more efficiently.

“The farms reasonably heavy and holds on very well through the dry.” - Farmer Informant 3

The variation of soils and drainage of ground in the Grey Valley (Fig. 3.7) can be observed simply by analysing the pattern of irrigating in the area and the rate of dry off during drought events.
Some farmers noted that the soil properties change dramatically across the property, requiring prioritisation of installing irrigation to one side of the farm, over the other, as shown in Fig. 5.5. Farmers who had varying soil types within a property were prioritising the segments with sandy and alluvial soils as they had less water retention appose to the heavier gley soils and clays. The below statement describes a farmer on the banks of the Grey River who manages the various soil types on the farm

“We now have 3 pivots on our bottom side which is the lightest ground, we are now about to irrigate our top side which is the heavier side.” – Farmer Informant 10

The acknowledgement of soil profiles changing within properties occurred in a range of the farms with the farmers noticing diverse response of the land to water (or lack of). The shallow alluvial soils that a number of farmers manage are the most challenging during drought events, as they do not retain the necessary moisture for sufficient pasture growth.

“Parts of our farm on the terraces dry off much faster, shallower base, there’s only about a foot of soil and then it’s just gravel” - Farmer informant 9.

An interesting point brought up by farmers was that the humping and hollowing done originally to assist drainage during wet weather had actually made them more susceptible
to the drier conditions as the ground drains a lot faster, in addition to impacting their ability to establish particular irrigation such as centre pivots.

“Because a lot of our ground has been humped and hollowed – it’s very shallow and alluvial; when we get the prevailing southerly winds and hot temperatures (up to 36 degrees) the grass burns off in 6 to 8 days.”- Farmer Informant 8

Although the knowledge of soil characteristics on farms has been common knowledge for the Grey Valley dairy farmers, the extent of the impact of the 2012-13 event gave farmers an idea of how quickly particular soils dry and the effect of that on pasture growth and ultimately, production. The farmers who established irrigation post 2013 had an idea of the sections of the property that were more prone to drying off, confirming the observation that experience is an important component to establishing efficient drought response. These statements do raise the question of priority for these farmers in this situation. Do they retain the existing humping and hollowing to aid them during wet weather, which occurs in high frequency, or do they remove the humps and hollows to aid them during drought events that are becoming more detrimental? The farmer’s decision making processes need to attempt to balance the mitigation of wet event impacts and dry event impact as one seems to be disadvantageous to the other in many cases.

5.1.2 The Grey Valley Climate

The climate was an obvious aspect that farmers are highly dependent on when deciding how to cope with drought. The West Coast is a region known for its high rainfall, with an average annual rainfall of 1900 mm (Mew and Palmer, 1989). The occurrence of the 2013 drought event caught out many farmers and industry players who were not prepared, and as a result were adversely affected. Many of the farmers as described throughout the interviews in the Grey Valley were affected by the unusual climatic conditions, but it was the nature and extent of the impacts that differed between the farms. It was expressed that during the 2013 event, in addition to the extreme lack of rainfall, the air temperature experienced by the farmers were unusually hot for the area (1.2°C in February 2013 and 1.6°C above average for March 2013) and added strain to the already stressed pasture (Tait, 2013; Tait et al., 2013). A similar scenario was experienced throughout the valley resulting in additional long-term damage to pasture due to the grass “burning off” which refers to the pasture drying and taking on a brown colour due to intense heat and lack of moisture.
“We do dry off, that wind is hot, I mean it’s only been five days and it’s starting to dehydrate, it doesn’t take long. It gets hot up here; it was 30 degrees a few days ago. A week in that hot weather and growth just stops” – Farmer Informant 4

Pasture burn off was a dilemma faced by numerous farmers who expressed disbelief at the speed and severity of their pasture burning off, with many using their winter feed and externally sourced supplement to ensure stock were fed. In addition to the lack of rainfall described by the farmers, the high temperatures and prevailing winds intensified the already very evident impacts on the pasture and the consequences of that on the rest of the farming system.

“When we get the prevailing southerly winds and hot temperatures (up to 36 degrees) the grass burns off in 6 to 8 days in certain parts.” – Farmer Informant 8

The severity of this particular event became obvious when farmers implementing a variety of response methods were still being impacted. The use of irrigation tended to provide a buffer that protected farmers from the full extent of the event’s impact even considering themselves far better off than many without irrigation. The farmers who irrigated strongly expressed their confidence in the benefits they observed on their own properties, indicating that it was the action that reinforced their farming system and got them through the event without severe damage.

“Those who didn’t have irrigation, I suggest would have had (accumulative effects). One of the grass species in particular had severe burn off.”- Farmer informant 5

According to many farmers the variation in rainfall throughout the valley was relatively noticeable. The rainfall patterns described by farmers have been recognised in the Grey Valley particularly with the more westward areas receiving an increased rainfall in comparison to those more inland (Molloy, 1988).

“The guys (dairy farmers) down by the river though are more susceptible than here (westward of Grey River – sheltered valley) and the guys (dairy Farmers) in the centre of the valley generally have a lower rainfall.” Farmer Informant 6

The variable weather conditions paired with the topography of the region has an impact on the distribution of rainfall at a local scale and was observed by the dairy farming community (WCRC, 2011). It has also been observed by farmers that the weather patterns in the Grey Valley have changed over time. Many have described the conditions becoming hotter and dry periods becoming more extensive and common, others have described the
climate to be similar, but the change in land use to be the culprit for the impact of recent droughts.

“We’ve had dry years before, historically if you go back 10 years and before it was all dry stock and all we had to do was hang around during a dry period. The Grey Valley is one of the best places in New Zealand for reliable autumn growth. Dry spells are not a new phenomenon but the land use has changed” - Farmer informant 5.

The majority of farmers recognise the change of land use amplifying the impacts of dry events in addition to the demand for water resources that comes with the increase in intensive dairy farming in the Grey Valley (Fig. 5.1). It was suggested by the farmers that the change in both land use from dry stock to intensive dairying, and increased pressure on the Grey Valley’s ground and surface water may be a key contributor to drought in the area.

5.1.2.1 Implications of Physical and Climatic Influences on Grey Valley Drought

The physical and climatic characteristics of the Grey Valley, West Coast, make it a distinctive region consisting of primarily mining and agriculture. The farmers of the Grey Valley have had to adapt to a combination of physical characteristics in order to effectively farm the land. When discussing the Grey Valley farmer’s ability to respond to drought, the physical components play a crucial part in which response strategy suits each individual farmer. The three primary physical aspects that the farmers have to manage are the geology, topography and climate, which present challenges not usually faced by farmers in other agricultural regions in New Zealand.

The Grey Valley sits on a mixture of alluvial gravels and soils with some areas of exceptionally high drainage (Landcare Research, 2014). The lack of water retention of a soil profile with these characteristics has played a significant part in the ability of farmers to manage the frequent high intensity rainfall events that occur in the area. Many areas that sat upon heavier, denser soils were quickly modified by farmers using the humping and hollowing technique to increase the land’s draining ability, preventing pooling and flooding. The modifications carried out on the land to achieve the desired condition on the farm sites have indeed been effective in mitigating the impacts of extended high intensity rainfall, and have actually allowed farmers to take advantage of an abundant water resource that many farmers in agricultural regions around the world are severely lacking.
On the other hand, the modifications made to the land have made the farmers vulnerable to dry periods. The soil types of individual farms of the Grey Valley do vary quite dramatically within each property meaning the overall management strategy of each farm will consist of a number of micro management systems catering to the various soil types. This was a theme that was present throughout the interviews as mentioned above. The challenges regarding farm soil types in other New Zealand regions differ quite dramatically to those on the West Coast (Radcliff and Cassens, 1974), with many having heavy soils with high retention properties and still suffering from drought conditions due purely to how extensive and severe the event is. The Grey Valley faces an unfavourable reality, which means that the farms begin to suffer the symptoms of drought more rapidly due to the extreme lack of water retention (Woodward et al., 2001). The addition of the humping and hollowing has increased the vulnerability of these farms further removing even more of the heavier soils and converting them into high draining land. As a result, the farmers have a much shorter window before the negative impacts of drought are felt giving them less time to prepare, presenting the possibility of the unfavourable conditions being experienced more often. The reality of this situation has resulted in new management strategies, such as irrigation, being necessary in the Grey Valley where many thought there never would.

The topography of the West Coast also presents an additional challenge to the farmer’s drought response to do the inconsistencies in terrain. When comparing the terrain of the West Coast with highly agricultural regions, such as Canterbury, Waikato and Southland, it becomes obvious there is a lack of flat, uninterrupted ground to establish pasture. The topography present challenges with response to drought as was mentioned by Informant 6 who described his farm as being long and narrow preventing him from establishing a centre pivot. Issues associated with inconsistent topography are not usually an issue in the dairy farming communities, as the farms established in other regions are there due to the ideal flat vast topography. As many farmers saw the West Coast as a region of plentiful water (a resource that was never as abundant in other regions, such as Canterbury and Otago) they had to modify the usual management of farms to suit the very different land available for. Farmers perhaps converted long narrow stretches of land thinking irrigation like centre pivots was never an investment they would need and are now having to consider alternative measures to manage an increased frequency of drought events.
Challenges associated with topography, although in different forms, are common in agricultural regions all over the world, both old and new, with farmers being required to tailor their management strategies to suit the specific conditions they face on their farm (Alam, 2015). It would be important for farmers to consider these potential complications when purchasing a farm with an unusual profile, and to have had some thought as to how unfavourable events such as a drought would be managed.

The challenges that have been associated with rainfall in the Grey Valley are beginning to shift from managing primarily unfavourably wet conditions, to having to have strategies in place to manage both extended wet and dry periods. The variation in rainfall among the farms of the Grey Valley have required farmers to put in place a customised farm management strategy that considers the adverse impacts of the extreme variations of rainfall being experienced in the region (Fig. 5.6). Landscape features such as the Paparoa Ranges also have a significant impact on the distribution of rainfall within the area. It could be argued that rainfall is the most significant physical characteristic to farmers and is a determinant in the management of the properties of the Grey Valley. The dependence that West Coast farmers have become on the normally consistent rainfall has put them at risk of not being effectively adaptive to changing climatic conditions. Dairy Farming is a water intensive farming practice, which began to take advantage of the high rainfall on the West Coast. Although the rainfall allowed farmers to undergo farm management without too much consideration of efficient water use, the combination of high drainage soil and
recent extended dry periods are making farmers question their current approach and attitude towards water use. There have been major agricultural regions that have had to dramatically alter current practices or cease particular practices all together, purely due to changes in rainfall patterns resulting in water scarcity and drought. A perfect example of this would be the scenario currently being experienced by the Murray Darling Basin, which produces between 30-40% of Australia’s gross agricultural products (Leblanc et al., 2009). The agricultural industry within the Murray Darling Basin depends immensely on the rainfall in the region to supply its extensive irrigation scheme, and has begun to suffer tremendously with the multiyear drought and overall water scarcity of the region (Ballard et al., 2014). The demand for water in this area has reached a point where the supply is no longer sufficient and has driven local and national authority to step in and enforce stringent restrictions on water use in the area (White et al., 2001). Although far more extreme, this was similar to the scenario that was experienced during the drought experienced in the Grey Valley in 2013. The Grey Valley farmers were so accustomed to the reliable supply of water that they were not prepared when that availability was compromised. The industry informants and the local authority also felt sudden apprehension in the later stages of the event, resulting in changes in both support structure and policy. The Regional Council realised they had over allocated water from numerous waterways in the upper Grey Valley, and funds were invested to increase the understanding of this water source in an attempt to regulate water takes more effectively. Previously, farmers were granted water takes without extensive monitoring due to the lack of experience the region had with dry periods. This resulted in the allocation of 20% being at 21%, requiring actions to be taken to decrease water being removed from the system. The policy reforms undertaken by the West Coast Regional Council were especially significant once it was realised that irrigation was a strategy many farmers were relying on to offset the impacts of water scarcity or drought. All of these drought management strategies and policy reform are centred on rainfall, and the level of efficiency and sustainability depend on a certain level of understanding of the rainfall patterns, and the impacts that any future changes in existing patterns, not only on the West Coast, but in agricultural regions all over the world.
5.2 Drought Management Strategies Implemented by Grey Valley Farmers, Industry and Government during the Drought event of 2013

This section describes the information gathered and the significant themes identified within farming community of the Grey Valley, West Coast, when managing the drought event of 2013, and the impact that this event had on the everyday farming practices. The results were obtained during semi-structured interviews where the subject was asked a series of questions regarding their responses to the 2012/13 drought and the impacts of that on future response. The following results will be separated into three sub sections – The influences of the dairy pay out (5.2.1), on farm management systems (5.2.2) and irrigation for resilience (5.2.3) The above sections explain the impact of the dairy pay out on the on farm management systems and the decision making progress around establishing irrigation. Each section gives a clear explanation around actions taken, rationalisation and the repercussions of the chosen responses. The involvement of farmers, industry and local government is to explore the differing perception of the impacts of drought. Involving representatives from the above three parties allowed comparisons to be made regarding priority during the decision making process. Identifying the challenges faced at each level and how they converse during a drought is important to gauge the overall response of the whole rural community.

The farmers of the Grey Valley are subject to a range of circumstantial and environmental factors that influence their methods of farming and their management of events, such as the drought of 2013. Each informant was subject to combinations of environmental and management factors that resulted in their individual circumstances and response strategy. These factors included the various physical aspects of the individual farms (topography, soil and climate) and the interaction of these with the management styles of each farmer.

The farmer interviews varied in both quality and quantity as some of the farmers seemed slightly uneasy or did not feel as if their situation was applicable to the study. Others, however, showed great interest and offered extensive detail on how they responded to the 2013 event, and how their response strategies have shaped how they might response to future drought events.

The candidates involved in the interviewing process varied in experience, location and property size. The aim was to include a range of farmers with differing circumstances and
make any connections between demographics and physical aspects with the overall response of each farming unit. The experience levels of the farmers included younger, newly experienced farmers to multigenerational farming units. The size of the properties ranged from 202 ha to 672 ha and were located throughout the Grey Valley with the most southern being just north of Ngahere township and the most northern being at Mawheraiti, just south of Reefton (refer to Table 5.3).

5.2.1 Dairy Pay-out

One theme that was repeated among farmers, industry and authority was the impact of the pay-out on the decision making process undertaken by farmers when responding to drought. The dairy pay-out has been increasingly volatile over the last five years and questions are being asked by the dairy farming community about the extent of the impact the pay-out has on a farmer’s ability to farm, Between 2010 and 2015 the pay-out per kg of whole milk solids dropped from NZD $8.18 to NZD $4.69 (Fig. 5.7).

![Figure 5.7: Pay-out prices for whole milk prices between 2010 and 2015. Source: DairyNZ – New Zealand Dairy Statistics.](image)

In addition to this, it has become more imperative for the dairy industry to determine the best way to create a buffer, protecting the industry. As described by Informant 10, who operates a 440 ha farm with approximately 1500 cows, the pay-out both before and after the event has a huge impact on how the responded to the 2013 event.
“Irrigation gives me a large option; the investment in irrigation has paid off, especially last year (2013) and going forward. It’s just a pity we are in such a low pay-out, otherwise I would have put in the full 200ha for next season but we will only be able to do 100ha.” - Farmer Informant 10.

Informant 10 invested in pivot irrigation for a large portion of the dairy unit, with more planned for the future. He indicated how the investment of any more irrigation depended highly on the income coming into the farm from the pay-out. The sharp decrease of the pay-out in 2013 prevented him installing the amount of irrigation he originally planned for the 2013/14 season.

The Local Government Informant 1 reiterated the points brought up by Industry Informant 1 and agreed that the response of the farmers was highly dependent on the existing financial position of the business; and the predicted pay-out for the season. When discussing responses with Industry Informant 2, the observations made regarding responses were more of a crisis response than thought through adaptive action. It was suggested that the lack of dry events on the Grey Valley resulted in farmers responding in a short-term manner instead of long term considered responses. The motivation for long-term changes would be the increased occurrences of these events, not just an increase in severity.

“Decisions made in response to increasing dry conditions indicate that the dry period was not a driver for decision making. If it became the pattern rather than the exception (extended dry periods) then you would probably see more considered responses.” - Industry Informant 2

The repercussions of this became obvious when discussing farmer approaches with industry who expressed that farmers lacked the preparedness due to them not expecting an event of that magnitude. Industry Informant 1 expressed how the event was more severe and extensive than what was expected by farmers, industry and local authority. The lack of preparation was what caught so many farmers out as they did not have the infrastructure (irrigation), and resources (feed) to continue milking through the event, without additional external sources being brought in.

“The actual severity of the drought took most by surprise, so when you are talking about contingency plans and levels of feed for both summer and winter, there were very few farmers that were equipped for that on the West Coast, I mean who would expect you to have a contingency for a summer feed program.” - Industry Informant 1
The high pay-out (NZD $8.51) in 2013 saved many of the farmers who had not put a drought management plan in place. He strongly believed that if the pay-out had been what it is today (NZD $4.30) the repercussions would have been significant, not only for the individual farmers, but for the dairy industry on the West Coast as a whole, he stated:

“So, when you look at a farm and you look at the expenditure and say, right, what is the most expensive thing on farm, you’ve got to say, well it’s either fertiliser, staff or fuel. These are the most important things, so if the pay-out is down, trying to gauge what priority is the highest gets more difficult. Responding to a drought becomes almost impossible because you still have all of those other cost factors involved with farming as well as responding to a drought. So, you can imagine your normal expenditure for stock feed, staff, electricity, fuel and fertiliser and add a percentage over that, there would be repercussions of a drought. That percentage would be dependent on the drought, so the more severe the drought, the higher the percentage is and the more that the farmers have to pay unexpectedly.”- Industry Informant 2

It was very clear that the pay-out was a significant factor that influenced the outcome of the 2013 event.

“I think the whole issue that has dominated how they responded that season (2014/5) was the pay-out so that was really the driving factor more than anything else, however having said that, in the back of their heads they did know that things were getting dry and they would need to think about doing something at some stage if it continued this way.”...

“They are more aware just how that would be manifested in terms of response I think; the significance of the financial component would be the biggest driver.”- Industry Informant 2

The impact of the pay-out on farmer response was primarily regarding the financial stability of the farming unit. It was suggested, especially by industry informants, that the more established resident farms were, the less susceptible they were to the effects of a low pay-out before or during a drought event. The more established farms were more likely to have had more time to pay off extensive bank loans and therefore were under less financial strain then those who had recently converted and constructed a new shed and so forth. The level of development already on a farm has a huge correlation with the amount of financial pressure on the system. The fewer infrastructures needed to be introduced to the farming system, the more room the farmers have to financially support an appropriate response to a
drought. This introduces the challenge of farmers having to decide whether to make large financial investment into irrigation. Establishing irrigation could potentially increase debt and financial strain, but increase the ability to respond to drought. The contrasting response would be not to make the investment but as a result not have the irrigation in place during a drought event. These conflicts are what the farmers are made to consider during the decision making process when developing a response strategy.

5.2.1.1 How does the Pay-out Affect Decision Making?

The findings that related to the dairy pay-out extended into most of the themes identified during the interviews. The information gathered highlighted the pay-out as an influential factor of drought response and identified is as being especially significant. As the dairy pay-out determined the financial resources available to contribute to the response, it is clear that the less earnings coming into the farming system, the more prioritisation and strategy that needed to be implemented by the farmer. The farmer’s ability to effectively manage the available resources during the 2013 drought varied among assorted demographics and a range of strategies were implemented to manage the effects of the event. The 2013 event in particular was unique as it affected the vast majority of New Zealand’s agricultural regions. The pool of feed available to farmers on a national scale was limited and it became clear that those who responded early and sourced feed had an immediate advantage over those who used externally sourced feed as a last resort, as by that point there was a limited supply and an ever increasing demand. The way in which the Grey Valley farmers responded to the 2013 event was highly influenced by the sizable dairy pay-out during the drought with the increased financial stability acting as a buffer, allowing them to have the means to be able to purchase extra feed or transport stock to more suitable grazing.

Industry members expressed concern over the occurrence of a similar dry period during a low pay-out season and the impact that would have on West Coast farmers. It was suggested that the pay-out paid a huge role in farmers having the ability to manage the 2013 event and questions have been raised as to whether some of the Grey Valley farmers have the long term financial support in place in the event of a future drought scenario on the region.
The continuation of a favourable NZD $8.50 milk solid pay-out following the 2013 drought event did also assist in the proactive decision making made, especially regarding the investment in large scale irrigation projects. Although the event had a financial impact on the farming units, in some cases, there was still enough to give farmers the ability to think ahead and prepare for future drought scenarios. Although it was suggested that many of the farmers were establishing extensive irrigation without a thorough cost benefit analysis, the farmers have expressed that they have been more than happy with the outcome of the investment. The complications surrounding the sudden increase in irrigation within the Grey Valley became apparent when authority were faced with the task of managing the water resource in the Grey Valley cautiously when they had never had to in the past. The impacts of a single aspect, such as the milk pay-out, has trickled down and impacted not only the farmers, but industry and local councils. It was implied that the spike in the irrigation in the valley would not have occurred without the increased pay-out as farmers simply would not have been able to afford it.

The volatility of the dairy pay-out over recent times in addition the increase in uncertainty over climate stability is cause for concern for those within the New Zealand dairy industry. It does present the complex nature of the global dairy industry and what actions are going to be taken by Government, industry and farmers to ensure that dairy remains a lucrative and dominant industry in New Zealand.

5.2.2 Farm Management Systems

The importance of farming management style when responding to an extreme climatic event such as drought cannot be overstated. Of the 11 farmers interviewed during this study, a range of different management strategies emerged and the influence of these on the impacts observed during the 2013 drought became clear. When discussing the term “farm management” it is referring to the strategies being implemented by the farmer on both a temporal and spatial scale. The significance of farm management systems was confirmed during the interview with Industry Informant 1 who identified that management strategies were indeed diverse among the Grey Valley farming community. Appropriate examples of the response undertaken by established farming units are the multigenerational run farms that occur in the region. Out of the eleven farmers interviewed, Farmer Informants 2, 8 and 5 were multi-generational farms. The farm sizes of the multigenerational farms that were interviewed had farms ranging from 206 ha to 500 ha,
with stock rates of between 360 and 800 cows. The confidence in their farming practices suggested that knowledge of farm history imparts a significant component in managing the property during drought. These farms developed a tailored and effective management plan, and as a result, were not affected as severely by the 2013 drought event as some of the other farmers. They tended to consider the timing of their responses almost as important as the response itself, relying on taking action early, such as dropping to once a day and sourcing external feed. Farmer Informant 2 confirmed that although there is common ground when regarding the level of establishment and how severely they were impacted; the actions they implemented differed considerably depending on other physical factors such as soil type and the overall farming style and experience of the farmers. The major differences in response regarded the use of irrigation and the production of on farm feed. Although Informant 2 did not use irrigation, they did not experience significant loss in production as their extensive feed input that provided the extra resources needed to keep stock condition even if pasture was being adversely impacted.

“We have so much input feed we only vary 5% in production anyway, that year (2013) we lost some production but we didn’t take a massive hit” - Farmer Informant 2

Informant 5 described the irrigation established on his property during the event with the addition of both K-line and pivot irrigation.

*Then we did one paddock of k lines as a trial to see how it went … We still have got k lines in some of the farm and have just started the pivot – Farmer Informant 5*

He explained that although it did not produce grass ideal for extensive grazing, it prevented pasture burn off saving him time and money as he did not have to re-grass paddocks.

*The main thing is loss of production and the other one is spending a lot of money re-grassing and you lose the plant density and I think that if it goes on for a bi the plant density is more of an issue then what people realise. – Farmer Informant 5*

The farm size and location is very similar between the two multigenerational properties owned by Informants 2 and 5, being 482 ha and 500 ha respectively and located in the mid Grey Valley. Despite these similarities there is a definite distinction in, not only the management of the farm, but the attitude portrayed by the farmers during the interviews. These two interviewees indicated that the 2013 drought event was not an unfamiliar occurrence and, therefore, they were able to offset the usual impacts of a drought as they had the necessary experience to effectively prepare. The common practices between these
farmers included both producing feed on farm and sourcing external feed, but the use of irrigation on one of the farms had a major impact on the dynamics of these actions. Many of these farmers also tended to reduce milking to once a day to prevent the health of the animals deteriorating. Seventy per cent of farmers put a strong emphasis that their priority during the 2013 event was to maintain the health and weight of their animals. The contrasting response to this was to ensure the animals were able undergo twice a day milking to maintain a consistent income during the event. The main issue that arose from this technique was that farmers who took this approach did not expect the drought to be as extensive as it was and had exhausted their feed sources too early. This was confirmed by the number of farmers who dropped to once a day milking, with more than half reducing their milking regime down to once a day.

“…because we thought it was going to come, in that drought we went to once a day” – Farmer Informant 2

The objective of this was to:

1. Keep the stock in good health as stated by informant 4 below

   “…the cows were losing production so I had to keep an eye on animal welfare, as they were losing a bit of weight. I kept this up for about two weeks before I pulled the pin on twice a day milking and that is when we really crashed. Once I was at once a day milking they stopped losing weight off their back, I had to make sure they were not losing weight or it would have gotten worse for me” – Farmer Informant 4

2. To ensure the available food resources were going to last the duration of the event, informant 1 clearly expressed the importance of this to mitigate the impacts of the event on his system.

   “Well because we had 60 ha of k-lines we were able to put the cows on 16 hour milkings and lengthen our round, then drop to once a day milking. Using our irrigated land and bailage, we still managed to milk right up to when it started to rain.” – Farmer Informant 1

3. Informant 11 described his decision to go to once a day milking was a response to a lack of water to undergo tasks such as washing down the shed. This is an extreme example of the effects the drought had on an upper Grey Valley farm and its ability to carry out normal operation.
“We had to dry off sooner mostly because of the (lack) of water to wash down the shed. It affected our well; we had to drill another well, adding to the financial impact ($12000) all because our main well had gotten to the point where it could not be used for the shed”—Farmer Informant 11

The consequence of this was farmers then needed to purchase extra feed from the West Coast, and other regions to maintain the desired level of milk production. During the later stages of the event, farmers were finding it difficult to source external feed, as there was very little still available. This put these farmers in a concerning position where they were running out of the feed needed to maintain the twice a day milking routine potentially putting the health of the animals at risk. There was a link between the decision to reduce milking and the demands for externally sourced feed. Attempting to maintain the twice a day milking routine throughout the event either put a significant strain on feed resources, or resulted in farmers having to stop milking altogether stopping income coming in at all. With the farmers that reduced milking earlier, there was still some income coming in and they were not using as much of their feed resources to maintain a once a day milking routine.

When discussing the impacts of the 2013 drought with the farmers, there was a range of impact levels. There were some farmers that did not feel that they were adversely impacted by the event, and some that described some relatively severe effects on the farming system. Although the severity of the associated impacts of the drought on each farm did not correlate with any physical factors (farm size, herd size, irrigation), the timing of responses appeared to be a significant factor influencing the impact on a farming unit. Those who made responsive decisions, either before, or in the early stages of the drought, were better set up to cope with an extensive drought period. Those who left the decision making until later were scrambling to find the necessary feed and were forced to make decisions in a highly stressful situations resulting in potentially poor decision-making processes. The decision to respond earlier by, for example, dropping to once a day, depended on multiple factors including debt/financial flexibility and amount of available feed. The farmer responses, when analysed by Industry Informant 12, were considered to be mostly quick instinctive decisions and had perhaps not undergone thorough consideration. The responses he referred to were mostly regarding large-scale pivot irrigation.
“They wanted to extend the area they were irrigating. By far the greatest proportion of those decisions were based on “knee jerk” intuitive responses rather than considered responses.” – Industry Informant 12

The circumstances that surrounded this event were unique as the drought was affecting a number of feed producing regions in New Zealand. This led to a demand for supplementary feed with an insufficient supply resulting in those who had left buying in feed until the last minute were risking not obtaining what they needed to maintain stock. The domino effect that occurred from this was what pushed farmers to resort to selling or culling stock as they did not have the means to sufficiently feed their existing herd.

“We put the cows on once a day and culled cows early, guess they were the major strategies” – Farmer Informant 6

Those who had not been adversely impacted by the event recognised that the most severely impacted farmers were those who had tried to ride out the drought, while continuing normal farming practices, instead of modifying systems to cater to the conditions the drought had presented. Those who were adversely impacted may have done so not expecting the event to be as extensive as it was, and by the time they decided to respond feed had gone up in price and was much harder to obtain due to national demand.

As the interviews progressed, the information collected suggested that the combination of physical and behavioural aspects of the interviewees made each farmer and each property unique. When analysing the information gathered in the interviewing process it became clear that some system of categorising farms into new or established was an important tool to determine any correlation between severity and the level of robustness in a farming response system. There was a definite range among the 11 farms included in the study with some only having 5 years on their property and some having up to 50 years’ experience. It became obvious that the more time farmers had been on a particular property, the more familiar they were with the way the land carried water and the local climate. Two of the farmers specifically said that they could “feel the drought coming” and so responded early – giving them the head start that they needed to respond accordingly.

5.2.2.1 How Does Farmer Experience Influence Drought Risk Management?

The farms of the Grey Valley comprise of a range of farmer demographics with various backgrounds and levels of industry experience. The dairy industry began to expand and intensify with the discovery of the affordable land and availability of abundant water on
the West Coast. Many farmers from other regions joined new farmers in converting extensive areas of the Grey Valley from dry stock farms to dairy farms to supply the West Coast based Westland Milk Products. The dairy industry in New Zealand has expanded with an increase in industry specific research and technology, improving farming systems and increasing production on farms in varying environments.

The farmers of the Grey Valley faced the challenge that the majority of other New Zealand farmers did not need to manage, the 1900 mm average rainfall that the valley received every year. As dairy farming is a water intensive farming practice, it must have seemed to be an ideal location where lack of water was not an issue they would need to overcome.

Research was carried out to provide information on how the farmers were to manage the extreme high rainfall eventually determining that creating high drainage land was the most suitable option. This resulted in the regular use of humping and hollowing systems. The dilemma that the Grey Valley farmers were faced with was the acceleration of dry period’s effect on the farming system as a result of the modifications made to manage high rainfall.

The establishment of humping and hollowing during the conversion process did give the land high drainage properties, and make it susceptible to dehydrating as the soil profile has very little moisture retention potential. This is an ideal example of how on farm management for high rainfall scenarios have in turn left the farm open to increased risk during drought conditions. As the farms in the Grey Valley became more established, the management of wet weather became a normal response for the region’s farmers. What many never expected to deal with was extensive dry periods and drought conditions, therefore adapting the farming systems to cope primarily with wet. Over the development of the Grey Valley dairy community, there have been dry periods that the farmers have had to manage with the events becoming more frequent and severe. The prioritisation of management to cope with more common circumstances in the Grey Valley has been an implication that had led to the farms experiencing difficulties when establishing drought response strategies such as irrigation. This situation has highlighted the importance of establishing a balance in the management system to cater to the impact of one extreme without hindering the farms ability to effectively respond the other.

A major theme that became apparent was the diverse response strategies within such a small, localised rural community. Response diversity is a reality in many global rural communities and demonstrates the different decision making processes carried out by the farmers (Alam, 2015). Although many response strategies are pooled into themes, each
farmer has a very individual set of actions to manage drought conditions that are based on
their specific circumstances such as geography, soil characteristics financial situation and
climate. It is the unique combination of these factors that allows the farmers in such a
small rural community to have such diverse response strategies to drought. An additional
element having an increasingly apparent influence is the farmer’s experience in managing
drought either in a generalised sense or on a specific farm. The impact of having
experience with a specific farm over consecutive seasons allows the farmer to become
familiar with how their land responds to seasonal climate. The complications that are
arising from land specific experience is the uncertainty associated with global climate
change triggering drought events in rural regions all over the world (Alam, 2015).
Although the more established and multigenerational farmers have been better off during
previous unusual drought conditions, it has been suggested that they may find it difficult to
adapt to climate variability generated by global climate change. By conforming to the
responses that have always worked in the past, could the more traditional farmers be
imparing their ability to adapt to changing conditions and be sustainable in the face of
imminent climatic change? These have been questions raised by global agricultural
industries and has been what has spurred the recent research into how farmers from various
regions manage adverse climatic events (Li et al., 2015). On the other hand, the newer
younger farmers did tend to be more open to taking more risky approaches and may be
more receptive to the approaches being made available with the increase in industry
specific technology and education. Although the more established farmers were some of
those least effected during the 2013 event due to their farm system stability, the younger,
newer farmers may have been exposed to newer industry developments with the increased
availability of industry education such as full tertiary courses. Although the more
established farmers may have more practical on farm experience, the addition of the
technical knowledge may be an advantage to the newer younger farmers.

An additional element that was present was the multi-generational farm management that
was prevalent on the farms involved in the interviewing process. Three of the eleven
farmers interviewed had involved either a parent or child in the farm management, giving
the system the advantage of having the experience of the older generation and the openness
and technological knowledge of the younger generation. The three farms that adopted this
management strategy were some of the least impacted by the 2013 event suggesting they
had established an effective balance that dealt with the challenges efficiently.
The concept of sustainable farming has become a significant area of research attempting to assist industry in giving the farmers the appropriate guidance and resources to future proof global agriculture, especially in developing countries (Li et al., 2015). Although the management strategies of the Grey Valley farmers are diverse, the desired result is similar, to have a strategy in place to mitigate the adverse effects of drought and ultimately maintain production in a cost effective manner. The challenges faced by these farmers are not only the potential of more frequent drought, but changes to policy and new regulations regarding water use. In other agricultural regions such as those in Europe, farmers have been not been pleased with the changes that have forced them to alter the strategies they have had in place for years (Iglesias and Garrote, 2015). These changes were forced after policy reforms took place following an increase in dry periods as a result of climate change and water demand in the agricultural industry. This case illustrates the challenges faced by the farming communities, as drought became more frequent, and gives an indication of the approach that the Grey Valley farmers may have to take if they experience the same scenario. These case studies confirm that even agricultural regions that are not particularly prone to drought are at risk of changing climatic conditions resulting from climate change. The advantage these regions currently have is learning from farmers, industry and local/national authority of regions who have had to manage drought for many years.

5.2.3 Irrigation For Resilience

One of the primary response changes that occurred in the wake of the 2013 event was a significant increase in irrigation being installed in the Grey Valley (Fig. 5.8). The use of irrigation in the past had been minimal with few farmers using it throughout the entire region. The occurrence of an event as severe as that experienced in 2013 pushed farmers to invest a significant amount of money in extensive irrigation systems.

“After the 2013 drought we did have an increase in applications, not a massive increase, for example post drought we were getting 3-4 a month opposed to 3-4 a year so they weren’t that common (pre drought).” - Local Authority Informant

The Local Authority Informant highlighted that the use of irrigation was not something many people could comprehend due to the view that the West Coast was a high rainfall region that was normally reacting to flooding. This view reiterated experience with farmers, industry (Westland Milk Products, DairyNZ and the West Coast Regional Council.
“Who would have thought you were going to have irrigation on the coast. I think in 2012, I think we maybe had 2 irrigators in the Grey Valley and now we have 12 on one farm.” – Local Authority Informant.

This reinforced the idea that the West Coast farming industry, local authorities and farmers did not consider drought to be a realistic issue they would have to deal with. Farmers showed a similar attitude with some still believing the event was not a common occurrence with some changing their stance after the event and some remaining in the same mind-set. Although adversely impacted by the event, some farmers did not believe that the event was worth investing in preparations for drought based on a single event.

“I thought, let’s not panic here and see what happens in the next few years and we haven’t had any issues.” - Farmer Informant 6.

A number of farmers, however, used the 2013 event as justification to invest significant money on establishing a drought response system. Most of these consisted of either newly establishing irrigation on a property or adding more to an already existing system. Many described plans for future expansion in his current irrigation system spurred on primarily by the severity of the 2013 drought.
“I think the only thing it did have an effect on was maybe made me want to think we want some more irrigation, 60 ha possibly would be enough if the K-lines were a bit more efficient but it’s not enough for what we want to do so we need another 80 ha on top of that”. - Farmer Informant 1

The farmer informants were at various stages of considering irrigation with some, like those mentioned above, relatively decisive about what they wanted to do. A number of the farmers, however, were at the planning stage, still doing cost benefit analysis.

“I have looked at irrigation and looked at how much it’s going to cost to grow feed under an irrigator versus non irrigation and talked to the farmers in the area about how many hours a year they run, which is about 800 hours and it became fairly cheap to put a pivot in.” - Farmer Informant 4.

There were mixed opinions among the industry and authority informants with various perspectives. Industry Informant 3 had extensive experience working with the farmers of the Grey Valley and assisting in the establishment of irrigation systems on numerous properties, including many of the informants involved in this study.

“The attitude back (pre 2013 drought) was this is a one off and the extreme length was a one off but what we have seen in the last couple years is that it’s not a one off.”- Industry Informant 3.

It was also stated that there were farmers that made the decision to irrigate during the event but believed that by then it was too late to be effective.

“We are getting longer dry periods, where we used to have 6-7 days of fine weather with a couple days of rain, we started getting 12, 14 days of fine weather and then we get the rain. By then the pasture has already turned and it is too late.” - Industry Informant 3.

It was also believed by industry that many of the farmers who responded to the event by established irrigation responded impulsively

“I guess there was more interest in irrigation; those who irrigated discovered that they didn’t have quite enough irrigation to completely manage the dry effect. They wanted to extend the area that they irrigated. By far, the greatest proportion of those decisions were based on the “knee jerk” intuitive responses rather than considered responses. “I need irrigation” without looking at doing the whole cost – benefit analysis.” - Industry Informant 3.
There were varied opinions among the interviewed farmers with some being completely against irrigation and some swearing by it. A number of farmers were concerned with the sustainability of irrigation on the West Coast, and as a result did not consider it as a drought response option. Four of the farmers did not consider irrigation to be an appropriate and sustainable addition to their farming system believing that the drought was a one off event and that they would not consider establishing irrigation unless drought event became a common occurrence.

“We don’t irrigate, irrigation is the best but we just don’t think it’s going to last, everyone irrigating have taken water meters, it certainly affects the Little Grey, even after a flood, it was down to a trickle because they (farmers) were sucking so much out of it. The Grey Valley has no holding power, any moisture during a flood just leaches out, so its (irrigation) got to come out of the river” - Farmer Informant 2

On the other end of the scale, 60% of the interviewed farmers did establish irrigation and swore by it expressing confidence that the investment would pay off if it had not done so already. These farmers were more than certain that their choice to irrigate was the most suitable way to respond to drought. A primary component that was involved in the decision to establish irrigation was the financial position of the farmer, and whether the investment was, firstly realistic and whether the benefits of the irrigation would counteract the additional financial strain of the investment. Irrigation units provided by a local irrigation specialist range from $5000 to $9000 per hectare depending on the chosen equipment, indicating the risks associated with the establishing large-scale irrigation system.

“I don’t think I would have physically been able to financially survive (the 2013 drought) if I hadn’t have had my irrigation. If you can afford a pivot, you do it, the returns are great.”- Farmer Informant 10

There did not seem to be any obvious pattern in the occurrence of irrigation in the Grey Valley as there were no correlations with location, size or stocking rate. After additional investigation, the farmers were placing their irrigation on high draining soils that dried off faster such as the alluvial soils that occur on the river plains throughout the valley. In addition to soil characteristics, the farmers ability to be financially able to invest in large-scale irrigation also played an important role in the decision making process.
5.2.3.1 Is Irrigation in the Grey Valley a viable Proactive Management Strategy?

One of the increasingly prevalent management tools being implemented in the Grey Valley dairy farming community is the establishment of various types of irrigation like pivots and k-line systems. These were a sight that had rarely been present on the West Coast until after the 2013 drought event, but were adopted by many farmers due to a combination of both a high dairy pay-out and the impacts of the extensive dry period. Surprisingly, it was a mixture of both well-established and newer farms that had invested in large scale irrigating units along with smaller k-line systems. The appropriate use of irrigation in the Grey Valley, and in agricultural regions all over the world has been debated for years, with increasing concern about whether it can be maintain in a sustainable manner that does not impact the long term health of the waterways being exploited. The West Coast Regional Council had to reconsider their current policy after they realised that particular rivers in the Grey Valley had been over allocated as the council had not managed past water takes effectively. The restriction on water takes in these regions may seem to be a hindrance to the farmers involved, but is a necessary action to ensure the sustainable use of the water resource. The implementation of more stringent policy may also be an incentive for farmers to improve the efficiency of their existing irrigation systems, ultimately saving them time and money. Policy modifications such as this have taken place in other agricultural regions all over the world, such as the agricultural regions of Alentejo, Southern Portuguese. The objectives of the new policy put in place in Alentejo was to prevent the overexploitation of the natural water resources, and to encourage the local farmers to improve their irrigation systems and use water more efficiently (Roxo et al., 2009). There have been numerous other agricultural regions that have had to undertake policy reforms with some such as California, USA and the Murray Darling Basin, Australia having extensive policy reforms to attempt to control the current water scarcity issues surrounding the huge scale agricultural activity (Ballard et al., 2014; Wilhite, 1986). As the demand for more irrigation increased in these regions, the complexity of the policy involved increased in an attempt to mitigate the impact of on-going drought events in the agricultural areas of California (Fig. 5.9).
It has been suggested that the increasing complexity of these policies have not actually had an impact on their effectiveness, and it is a high possibility that this would be a similar case if the policy reforms on the West Coast were to follow the same path. The complexity of the increased irrigation occurring in these agricultural areas have resulted in the reduction of the water available for both ecological and agricultural purposes with the need for agricultural reasons being priority numerous times. This was a scenario that has become a potential issue in the Grey Valley, with the authority not having the familiarity of establishing water regulations and limits for extraction. The result of this inexperience was an over allocation of water to farms from some of the major waterways of the Grey Valley. The authorities had to correct the situation by partially removing some of the water rights held by some of the farmers who had already been allocated water.

This is an example of how inexperienced water use easily results in unsustainable extraction and therefore a response that would not be a long-term solution. There have been multiple case studies that show the implications of unsustainable extraction, none more so then the Murray Darling Basin in Australia, and the western states of the USA (Ceppi et al., 2013; Zhang et al., 2015). The overexploitation and increased reliance on irrigation is a reality of the global agricultural industry and with the changes in global rainfall patterns. The ability to use water sustainably could be a crucial constituent in the
survival of a number of producing regions, especially those that have relied on high rainfall previously, such as the Grey Valley. The increase of irrigation in surrounding regions such as Canterbury and Otago has provided the West Coast with the resources and expertise to consider irrigation as a very real option. In recent years a West Coast based Irrigation Company, Think Water, has launched proving the demand for irrigating systems and expert irrigation knowledge, has increased.

When discussing the decision making process around the huge investment involved with irrigation, the farmers who had irrigation emphasised that they felt that the investment had been worth it with the irrigation allowing them to continue consistent production event during dry periods. A number of the farmers in the Grey Valley did feel that the use of irrigation would not be a long-term sustainable option for the dairy community in the area, due to the nature of the waterways being extracted from.

This divided opinion does raise an interesting opportunity to investigate the direct impact of irrigation on not only drought response, but on the overall effectiveness of the farming system. Does the establishment of irrigation prevent the farmers from adapting to climatic conditions by simply artificially modifying them? This question is one that brings up a number of points that question if farmers are better off modifying the physical characteristics of the area to match their farming system, or whether they should be considering modifying their farming system to response to changing physical characteristics, there is some debate about where irrigation lies. Is the use of irrigation considered a modification of the environment or as a response to the change in regional rainfall?

The effective and sustainable use of irrigation in the Grey Valley will depend on the absolute understanding of the physical characteristics of the land and climate and the careful application of these factors in strict regulation and policy before overexploitation of the water resource. The complications faced by other drought stricken agricultural regions in New Zealand and all over the world could be platforms to improve current water management but it is extremely important to incorporate the distinctive and unique environment of the West Coast. Although this is in very early stages in the region, regulatory and policy reforms along with government and industry funded research has begun to take place helping ensure that any decisions made are educated and will be supported.
6 Conclusions & Recommendations

6.1 Conclusions

The objective of this research was to determine the environmental and circumstantial factors that influence the decision-making that occurred before, during, and after the 2013 drought in the Grey Valley. An important component was investigating the roles played by the farmers, industry (Westland Milk Products, DairyNZ and Think Water) and the West Coast Regional Council, how each party perceived the responses to the event and how the event played a part in response strategies for the future. At the beginning of this thesis a number of questions were asked; not only of the farmers, but of all those agencies that should be involved in any form of drought response. The first part of this chapter addresses the key findings to these questions, and is followed by a set of recommendations for future drought management strategies in the Grey Valley.

Impacts on farmers

The impacts of the 2013 drought on farmers were dependent on a combination of environmental and circumstantial elements within the farm management system. The primary environmental elements that influenced the level of impact were the soil type, immediate topography and the microclimate of each individual farm. The impact of the drought was felt most severely on the quality and nutritional values of the pasture that farmers relied on primarily for feeding stock. The key impact of the drought on pasture was the grass burning off and dying resulting in an insufficient source to keep stock in good condition. The other impacts felt were simply a roll on effect from a lack of pasture. Firstly, farmers had to invest in supplementary feed, which introduced an additional unexpected cost. An additional work load on farm in an attempt to re-grass and distribute feed to stock was also an additional component that occurred during the event. The key impact that was the most concerning to farmers was the reduction in overall production, which ultimately decreased the income of the farming unit. A major mitigation of the impacts, especially during the 2013, was the high dairy pay-out, which provided extra financial resources to invest in the feed and to partly make up for losses made with reduced production.

Initially during the discussions the major impacts that were highlighted by farmers were on pasture, supplementary feedstock, financial, and overall farm production. The primary
priorities expressed by the farmers included the maintenance of stock condition, the continuation of production and reduction of stress on pasture all with the aim of reducing a cumulative impact on the production capabilities of the following season (Fig. 6.1).

Figure 6.1: key objectives of Grey Valley dairy farmer drought response and management.

**Cumulative effect on farms**

A primary objective that was incorporated into drought management strategy for many farmers was to avoid any impact of the event on the following season’s production. Measures taken to mitigate the impacts during the event were partly motivated by farmers wanting to contain the impacts to a single season. The impression given by farmers was that the strategies that they put in place achieved this, and although impacts affected the farming system on a short-term basis, the long term outlooks and on farm goals appeared manageable.

**Farmer mitigation**

The effective management of each individual farm during the 2013 event was highly dependent on the incorporation of environmental and circumstantial elements that have been developed from previous experience. The findings of the research indicate that the response to drought is based primarily on a case-by-case basis with farmers having a range of drought response and management strategies. Although each farmer had a strategy that
suited their individual circumstances, there were a number of themes that arose from commonalities between them. The three response actions that were mutual among numerous farmers were:

- The addition of supplementary feed into the farming system,
- The establishment of a range of irrigation solutions,
- Changes made to the milking routine, with many dropping to once a day.

Each of the actions described by the farmers came with their own set of benefits and challenges and it was clear that the farmers’ objective was to initiate a balanced strategy depending on their individual circumstances and addition of industry and local government pressures (rules and regulations). The most influential factors that were introduced by industry was the dairy pay-out together with regulations introduced by the West Coast Regional Council. Throughout discussions with farmers, the overall theme of the pay-out became clear as it introduced a financial constraint on what farmers could incorporate into their responses. Constraints of this nature have dominated decision-making and if not considered carefully, impact the overall effectiveness of the response by limiting what actions can be incorporated. The introduction of the financial component introduces a new dynamic to the decisions being faced by farmers. Do they invest in expensive drought mitigation measures, such as a centre pivot unit, and increase debt? Or do they take a less expensive approach that would not make them more financially vulnerable but would not provide the same drought protection and mitigation?

To increase the complexity of these decisions, regulation and policy add an additional component that would limit water extraction for farmers particularly in the upper catchments of the Grey Valley. For farmers that did not consider irrigation to be a feasible option, establishing a reserve of supplementary feed sourced on-farm and from external providers was a common action. Although some farmers relied on one particular feed, others incorporated several feed sources into the farming system with the key objective of having enough to sustain through winter with extra to maintain stock condition and overall production during a drought. In addition to the irrigation and the supplementary feed, a number of farmers would drop to once a day milking to firstly maintain stock condition but also to effectively regulate additional feed to ensure there is enough to get them through a drought. These management strategies have developed with both the existing experience among farmers and the introduction of new technological advances. Those interviewed
ranged in demographics, location, farm size, and provided a balanced cross section of farmers describing strategies and management styles.

The Grey Valley case study differs from the majority of the drought literature as it is a region with a high annual rainfall that does not experience drought frequently. The lack of drought, however, does not change the impact of the droughts that do occur on the farmers, the industry and the extended community and, therefore, should not be a determinant when increasing awareness and providing resources at both a local and national level. In each of the question being investigated in this thesis, industry strategy is an integrated part of farmer response and it would be noted that these strategies were mentioned when addressing the question of farmer strategy.

When comparing how the Grey Valley responded to the 2013 drought and the responses of other global examples, there are commonalities that occur from the initial responses that would have occurred in the early drought events. The common aspects include the correlations of changes of land use to more intensive agriculture and the pressures of that on the existing ground and surface water resources. The prime example of this was the concepts within Australia’s National Drought Policy 1992 which outlined the objective of encouraging actions at a farm level with on-going support from industry and government (White and Karssies, 1999). The increasing uncertainties that are associated with climate change are also a challenge that agriculture globally is facing as the decreasing confidence in future climatic conditions. As the frequency of drought events worldwide continue to increase, so does the experience and response knowledge. Considering the mistakes made by other regions that have experienced severe drought and justifying decisions and response frameworks with the available scientific literature will add strength to any drought response or management strategy. It is just important to incorporate the specific conditions and circumstances of each region into any adapted plan to increase effectiveness and improve the processes involved with putting any plan into action. The Grey Valley provided an example of a region that was in the initial stages of drought response with very little in the way of government or industry response strategies. The lack of a drought response plan has meant that farmers have had to implement their own strategy based on individual experience and circumstances with very little input from any outside parties and the implications of that are questioned.

After considering the information gathered throughout the literature and the interviews, the Grey Valley case study falls primarily into the water scarcity category as farmers have not
often had to consider the sustainable use of water due to its plentiful supply. The identification of the issue being associated with water scarcity should assist in ensuring that any developments made are done so to the overall management of water not just what should be done during a drought. By taking this approach, farmers, industry and government would encourage sustainable water use that would simultaneously, alleviate the impacts felt during a drought and would possibly benefit the Grey Valley dairy community throughout the year. Although this is the case in the Grey Valley, many of the available drought response case studies have faces the impacts of drought over water scarcity with extremely low precipitation over multiple years, which would require a different management approach.

The importance of incorporating multilevel input into drought response would be an approach that could benefit the dairy community in the Grey valley as a range of different experience and perspectives would provide a well-rounded strategy. Open communication between the farmers, industry (Westland Milk Products, DairyNZ and Think Water) and the West Coast Regional Council would result in all parties being informed, increasing the effectiveness of their response to a drought. The West Coast presents a particularly interesting case as the priority has always been to manage the land and farm system to cater to the wet climate that the West Coast has always experienced. While undergoing these modifications such as favouring high drainage, the farmers rarely considered that they would need to potentially manage a drought and that by decreasing the risks associated with wet conditions, they were actually increasing drought risk. By increasing soil drainage and reducing already low water retention in the alluvial soils of the Grey Valley, the farmers ultimately have made them more vulnerable to the adverse effects of drought. The repercussions of this were felt during the 2013 event, which led to many farmers establishing irrigation in an area where there was little experience and understanding of whether the existing water resource was sufficient to support intensive irrigation schemes. The security of the existing dairy industry in the Grey Valley would be far better understood if more research was carried out to determine the mechanisms that make up both the surface and groundwater systems.

Industry mitigation

The industries that are associated with dairy farming on the West Coast also have an input into the response strategies of the farmers. Industry response is characterised mostly by offering support by taking on an advisory role, instead of any explicit assistance to farmers
in the means of resources. The three primary industry parties involved, Westland Milk Products, DairyNZ and Think Water provided support in various ways ranging from simply checking up on farmers during the event, educating farmers on how to cope with the event, or raising national government awareness of the situation. Expert advice and consultation around potential mitigation strategies are also available to farmers from outlets such as Think Water. Industry strategy overlaps all of the questions asked in this study, as it serves as a link between farmers and the support available to respond.

**Local Government (West Coast Regional Council) mitigation**

The West Coast received very little attention from central government during the drought event of 2013 even while suffering similar soil deficits and drought related symptoms of regions in the North Island that had been declared a drought zone (Turner and Chappell, 2013). The West Coast Regional Council did not indicate any major movement to act during the event with no implementation of a drought response plan or overall guidance for farmers. The importance of understanding water use in agriculture resonates among the farmers, industry and local government, especially with the unexpectedly severe repercussions of the 2013 drought. There have recently been grants made to the local council by national government to investigate and increase the understanding of the Grey Valley’s hydrological system and what extent of extraction for irrigation could be maintained sustainably, or whether irrigation is a sustainable option for the area. The national Government’s approach to drought on the West Coast was portrayed as being little more than declaring the region a drought zone in the very late stages of the event, but by doing so made farmers able to apply for drought aid packages. These drought aid packages, in the form of tax breaks and loan holidays, were not widely utilised as the declaration of drought occurred largely towards the end of the event on the West Coast.

Together, the responses of the farmers, industry and local government in the agricultural economy of the West Coast illustrate that future decisions will need to be made regarding the direction of dairy farming in the Grey Valley. Collaboration of the three levels will be crucial in undertaking the necessary preparations, actions and regulation of approaches taken by the farmers to manage drought and reduce the risks that are associated with it. The understanding of each perception and an attempt to establish common objectives will create a close and cooperative multi-level approach that would allow for a single cohesive rural community response in the event of a drought. An effective response would be based on common goals of a collaborative unit that is aware of collective strengths and
weaknesses at all levels. An increased understanding, not only of the environmental components but the realistic use and management of them will encourage a more sustainable direction for the industry.

The West Coast Regional Council needs to prioritise studies of this nature, not only in the Grey Valley, but all over the region to increase the understanding the overall hydrology of the West Coast and whether it is capable to support a growing dairy industry. The regions will, at some point in the near future need to put a strategy in place that incorporates the specific constituents of a drought to build on the currently very vague plans in place that have been designed to cater for a variety of natural hazards. Although droughts may not be overly common on the West Coast, they can still adversely impact the agricultural activities in the region.

**Global Drought Events versus Grey Valley Drought Events**

Agricultural regions in numerous parts of the world have experienced drought events of various severities and have managed them using a range of strategies from farm level right up to state and federal government policy. A few regions have been experiencing drought for decades and have developed response and management strategies based on those events. The policies that have been built on the foundations of experience are a valuable resource for other regions that are able to gain understanding of what the benefits and consequences of particular responses are and what approach would suit specific circumstances of a region such as the Grey Valley.

Incorporating the experience gained during the 2013 event in addition to the research available from other drought prone regions could provide the Grey Valley with an effective strategy to reduce risk and decrease vulnerability of farmers to the adverse effects of drought. For a drought response plan to be effective on the West Coast, the specific circumstances of the region must be distinctly present in the design. The importance of having a plan prepared and ready to implement cannot be overstated as crucial decision-making would not occur during high stress and measures can be put in place quickly and effectively (Kiem, 2013). The input of government, industry and farmers in response strategies during the severe events experienced by regions, such as the Murray Darling Basin and California’s Great Plains, has provided an example of how multi-level response is such a central theme. The improvements that were considered to be ground breaking in drought response research and policy focussed on the government and industry supporting
the farmers by encouraging and funding advances in farm level actions to reduce the risks associated with drought. The idea of educating farmers and creating a framework to make them less vulnerable to drought has been the driver of proactive response and will ultimately be more effective in the long-term continuation of agriculture in drought prone regions.

The incorporation of the three levels of response into the questions asked during the interviewing process was an attempt to gauge, firstly how the farmers managed drought and secondly, what support they received from industry (Westland Milk Products, DairyNZ and Think Water) and the West Coast Regional Council. If production on the West Coast rose and their contribution to the national dairy market increased, would they receive more support in an attempt to protect the national market, or would the support remain the same? The lack of regional preparedness to drought at an industry and local government level could be due purely to the lack of drought events in the region, or the lack of resources available to effectively assist.

Drought is a phenomenon that will continue to adversely affect agriculture, despite the level of intensity, and it is essential to understand the local conditions and base response strategies around the limitations of water resources available at a local scale. Many of the regions experiencing severe and persistent drought are regions that are supporting hugely water demanding and unsustainable industries that have become reliant on the continuing availability of sources such as groundwater. An example of this is the completely unsustainable extraction from the Ogallala Aquifer in the USA where agricultural demands have depleted the groundwater resources to a point that has raised concerns about its use in the near future. A growing understanding of the system is revealing the urgency of action to prevent the complete depletion of the groundwater resources on the area (Hornbeck and Keskin, 2014). As case studies have emphasised, the increasing understanding of groundwater systems has begun to illustrate an unstable future for those who rely on it, with some cases already experiencing the implications of the overexploitation of aquifers. Groundwater is a source that is becoming increasingly common in the Grey Valley and in some areas was impacted to the point of running dry, leaving farmers with no water at all. Scenarios like this highlight the very real reality that Grey Valley farmers need to face and referring to global case studies that show the scenario that Grey Valley farmers may face if sustainable use of groundwater is not implemented.
Understanding the distinction between drought and water scarcity also proved to be an important component to consider when addressing drought response and management. Impacts being felt by drought, such as a lack of precipitation, are not able to be controlled and can be far more difficult to manage and mitigate. Impacts felt by water scarcity, however, could potentially be mitigated by changing the way the existing water resource is used (Van Loon and Van Lanen, 2013). Making the distinction between these two terms would be critical in ensuring the management strategies being considered are addressing either the non-controllable environmental aspects such as rainfall or the controllable aspects such as the management of water and the change of land use. The adjustment of global drought response from ‘crisis management’ to risk and vulnerability management is a direction that not only the West Coast, but New Zealand needs to adopt as agricultural intensity and water demand continues to increase, especially in the dairy industry. The shift to the overall management of water resources has proven to be difficult (Botterill, 2003), but the projected outcome if the change in management occurs is far brighter than if crisis management remained the primary approach to drought and water scarcity.

Research, such as this study, will hopefully provide motivation to industry to initiate plans designed to complement the experience of the regions’ farmers with the addition of global and New Zealand research on drought response. From the conclusions, the following recommendations can be made to promote efficient and effective drought response for the Grey Valley farmers, industry and local government to utilise for future events. The motivation for this research in the Grey Valley was the lack of research and attention that it received during and after the 2013 national drought event. As the West Coast is not a major contributor to national production or the global market in comparison to the Murray Darling Basin or America’s Great Plains, it was not viewed as a priority in the midst of national drought response. Such centralised perspectives are flawed, as the West Coast of New Zealand is one of the fastest growing areas of dairy expansion and investment presently, and it is short-sighted to discount the risk of drought to the region simply on the basis that it is a high rainfall area under typical conditions.

There have been numerous studies worldwide on regions that have suffered drought or water scarcity and how it was managed. The information that can be teased out of these case studies is valuable to regions such as the Grey Valley who are at the initial stages of developing drought response and management. Analysing how these global case studies for drought response and identifying the strengths and weaknesses of each response type is
luxury that many regions have not had when initiating response and management. The dairy community in the Grey Valley could potentially learn about mistakes that have been made in other regions and applying the lessons to a response plan. The issue of sustainable water use and irrigation is a central issue in most of the regions that suffered multiyear drought events. The understanding of the available water systems was only developed during, or after, an event where it was too late to change established infrastructure without major cost and repercussion to the farmers.

The Grey Valley has the benefit of experiencing drought relatively infrequently and has the opportunity to improve the understanding of the existing resources and establishing a sustainable level of infrastructure that would not result in severe water scarcity during a drought event. A key theme that was reiterated in the Murray Darling Basin and the Great Plains of California was the change in drought response to the management of drought risk and decreasing farmer vulnerability (Wilhite et al., 2000, White et al., 2001). Effective management of these risks requires enactment of sustainable practices that correspond with the available resources by exploring more efficient irrigation schemes. Currently the majority of irrigation in the Grey Valley consists of k-lines and centre pivots but could there are less intensive alternatives that may suit the hump and hollow topography of existing farms. The regulation of the established limits would be where policy and local government are involved. Investing in research to have a comprehensive understanding of the water resources and adapting agricultural activity accordingly in the early stages of Grey Valley’s drought management could mitigate or avoid the impacts of past mistakes made by other regions.

6.2 Recommendations

With the information gathered during this research, the following recommendations are approaches that could be considered by the farmers, industry and local government of the Grey Valley to increase the preparedness of the regions dairy industry to future drought scenarios. The West Coast economy relies on the few major industries in the region including dairy meaning that it is important to invest the appropriate time and resources to ensure that events such as drought do not adversely impact the overall success of the West Coast dairy industry.
6.2.1 Multi-Level management

The multi-level strategy that has been implemented in the Murray Darling Basin and the Great Plains of the USA are exemplars of multi-level management strategies that can be implemented in the Grey Valley. The incorporation of these concepts when establishing management and advisory roles provide a conceptual structure to work from that can be modified by input from farmers, DairyNZ, Westland Milk Product and the West Coast Regional Council. Creating specific roles within each level and organising monthly discussion groups where research findings can be shared and input given would is a good starting point to initiate conversation amongst the farmers. Supplying farmers with information in the form of pamphlets or a website that explains the benefits of managing drought risk by becoming more sustainable is an effective start. Appointing a position within the council or Westland Milk Products that concentrates on West Coast agricultural water use may also provide a link between the farmers, industry and council encouraging co-operation and collaboration. Ensuring farmers are aware they have support from industry, even just in the form of information and advice may result in them being more likely to participate and attribute their own individual knowledge and experience.

By promoting open and multi-dimensional communication, the hope would be to encourage farmers to discuss drought, not only to industry and the West Coast Regional Council but to fellow farmers in the Grey Valley. The integration of the knowledge, experience and resources of the farmers, industry (Westland Milk Products, DairyNZ and Think Water) and West Coast Regional Council will be important to ensure all bases are covered and all available resources are utilised efficiently. Documents that could be investigated and drawn upon are those that were developed as a response to the droughts experienced in the Murray Darling Basin, such as the Sustainable Rural Water Use and Infrastructure program or the Murray Darling Sustainable Yields Project (Department of Environment, 2015) (CISRO, 2008). The recent programs applied to the Murray Darling Basin have had the following primary objectives (Wilhite, 2005):

- To encourage primary producers and other sections of rural Australia to adopt self-reliant approaches to managing for climate variability;
- To maintain and protect Australia’s agricultural and environmental resource base during periods of extreme climatic stress;
- To ensure early recovery of agricultural and rural industries, consistent with long term sustainable goals.
All of these concepts can be applied to any plan or programs implemented on the West Coast, and are a valuable resource for those at all levels of the rural community of the Grey Valley. If these concepts were to be successfully implemented, the outcome would hopefully be a more sustainable dairy industry with low-level vulnerability to drought.

Securing a positive and open relationship between all parties will be beneficial to the overall objectives of a plan and can be achieved by holding on-going discussion groups to ensure all who want to be involved are updated and aware of any developments made. One of the benefits of being a small, close knit rural community means that incorporating a sufficient number of farmers should not be too challenging. Having a robust relationship between all involved at a local scale may increase the power of persuasion if support was ever necessary to seek support from national level government. Lobbying to national government as a cohesive unit representing all levels would come across far stronger and compelling if external assistance or support was ever needed.

6.2.2 Modification and Adaptability

For the majority of the time, the farms of the Grey Valley are faced with managing the adverse effects associated with wet weather. As a response to this, they have undergone what has been needed to mitigate these impacts with actions that decrease water retention in soil and increased drainage. The realisation now, is that these actions have increased the land to the impacts of drought and farmers are now faced with the problem of how to attempt to decrease drought vulnerability concurrent with managing effective drainage under normal conditions. Whatever strategies implemented by farmers must take into consideration both dry and wet conditions and so the importance of balanced management cannot be over stated. Many farmers are aware which parts of their farms are more suited to wet and which are suited to dry. Designing a rotation system that favours the high drainage paddocks in the wet to prevent bogging and heavier, slow draining paddocks to prevent pasture stress could be a realistic and relatively inexpensive approach. Investigating and strategically sewing specific species of grass into the best suited soil conditions may also increase pasture stability. Involving a number of grass species when regrassing paddocks may reduce vulnerability as some may thrive in particular condition while others fail. To many, irrigation has been the approach to decrease drought risk but there is very little understanding of the impacts of irrigation on water resources of the area. If irrigation is to become a major strategy used by farmers, it will be important for the
West Coast Regional Council to invest in research to attempt to comprehend what level of irrigation can be implemented and industry such as DairyNZ and Think Water could increase farmer education into efficient and effective irrigation practices. Having industry representatives, such as Think Water, holding seminars or presentations on the range of options available to farmers and taking an advisory role what system would suit individual farms would benefit the farmer, and Think Water as a business unit. As the majority of the time, the Grey Valley has a plentiful water resource, a strategy that could be considered would be investing in storage ponds that can be filled throughout the year and used during a dry period. In discussion with the industry representatives, there are some ideas and initiatives that mimic the irrigation storage facilities in central Canterbury and Northern Otago (Climo, 2015), initiatives are centred on potential storage facilities that enable farmers to store water in times of plenty, this will involve local government as an activity of this scale will attract requirements under the resource management act 1991. Rating schemes have worked well on the West Coast and this would be a ‘smart’ method to contain a valuable resource

Another input that may be more suitable would be an effluent irrigation system where water and effluent from the ponds is applied to the pasture. Not only does this provide water but also acts as a fertiliser further promoting much needed growth during a drought. The correct balance of the above components could allow for irrigation to be a viable option but it would be necessary to ensure that appropriate regulation and monitoring of water being extracted was achieved before farmers become reliant on unsustainable water use. Research into the possibility of water storage in the Grey Valley may also be an avenue that could be explored if irrigation is a dominant approach expressed by farmers

The Grey Valley is host to a small, close knit dairy farming community and it would not be difficult to achieve substantial interest from farmers if industry support was offered. Educating farmers by initiating monthly discussion groups or providing support to assist farmers at an individual scale in the way of specialist consultants would provide more crucial information and understanding, not only for the farmer, but for the industry and West Coast Regional Council. Involving guest speakers that specialise in a particular area such as irrigation, supplementary feed or overall decision making may encourage farmers to participate and would stimulate both thought and conversation within the entire Grey Valley dairy community. The overall concept of smart long term farming is that if farmers, industry and the West Coast Regional Council work together to improve the decision

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making and management systems on farm, the outcome both immediately and in the future will be beneficial at all levels.

6.2.3 ‘Smart’ long term farm management

Smart long-term farming on the West Coast would need to incorporate the traditional knowledge of the land and climate that the farmers possess with new technological advances in agricultural infrastructure. The knowledge and experience gained over the time spent farming in the Grey Valley will play an important part in knowing what systems would suit individual farms and industry and the West Coast Regional Council need to utilise this source of information from farmers. New agricultural technology, however, is the area of expertise for industry players such as Dairy NZ, Think Water and Westland Milk Products, and the involvement of these parties will complement the knowledge held by the farmers. The idea of smart or long-term management strategies would be to consider not only the immediate factors contributing to drought management but the possibility of any future changes. Incorporating future scenarios into the decision making process will increase on farm adaptability and encourage farmers to undergo critical analysis before making a decision. An example of this would be a farmer installing large-scale irrigation in an area with an unsustainable water source that would not be sufficient for agricultural use in the future.

By being aware of how that particular area reacted to previous drought, the farmer could gauge whether the installation of large-scale irrigation would be a feasible addition to the system. If deemed to not be feasible, the farmer could consider other options that would achieve a similar outcome. It is during the decision making process of farmers that the industry and local government knowledge will be most valuable. By educating farmers and urging those to make a decision based on up to date information and research, many of the issues experienced, such as those in the Murray Darling and Great Plains, may never occur in the first place.

By learning to identify, understand and manage the risks associated with drought and water scarcity, farmers can achieve the ultimate goal of reducing or eliminating their vulnerability to drought. It will be these decision making processes that will need continuing support from industry and local government on the West Coast and can be done by providing continuous information about new region specific research in addition to global case studies. Although many may look at the broader picture when considering the
concept of “smart farming”, it is the critical processes that occur prior to any action that will determine whether smart, long term farming is occurring or not. As the results have shown, it is not always one strategy such as irrigation or once a day milking that will be successful on every farm, but it is what information and experience each strategy is based on that is so important.

A potential initiative would be for industry and local government to encourage or provide resources to enable farmer to have access to equipment such as soil probes, on farm weather station, river flow readings and automated services (soil moisture, irrigation rate, rainfall). Uploading data from these devices to a shared webpage would give an overall idea of the condition being experienced by the farmer in addition to making farmers far more aware of their own land. Other service providers, such as fertiliser companies have attempted to calculate inputs on farm such as fertiliser, various methods have been trialled, and one of these is overseer. What has been established on the West Coast, is that the nutrient budget programme OVERSEER is incapable of calculating practical nutrient losses on farm due to the high rainfall traditionally received (Climo, 2015).

A lack of freshwater resource data on the West coast has always been an area for improvement as sustainable water management has not proven to be an issue that, especially farmers, have considered priority due to the sheer amount they deal with for most of the time. Establishing methods to gather and display data such as catchment flow and site specific rainfall data would be strong start to decreasing farmers’ vulnerability to water scarcity as they would be armed with a better understanding of the water related challenges they need to manage within their farming system (Gleick, 2015).

To conclude, the information gathered during this thesis will prove to be valuable to not only the Grey Valley, but also areas in a similar situation. The farmers, industry and West Coast Regional Council must develop future water management on the concept of sustainability and long-term risk management to avoid similar impacts during a future drought. It presents the question, if a region with an annual rainfall as high as that on the West Coast can suffer from drought and water scarcity, so can a number of other regions that may never be considered to be vulnerable. It highlights the primary issue of unsustainable water use and taking water resources for granted because they have always been there. The key theme that has come out of this study has been the absolute need for sustainable practices in agriculture all over the world regardless of the climate or available water resource. If the message of sustainable water use is not taken seriously agricultural
communities worldwide will face the impact of drought and water scarcity at some stage or another when they have avoided them altogether by improving overall water management. The discussions had during this study answered many questions but also raised a number of questions that could be the foundations of further study. Questions emerged about whether the time spent farming a single location impacted the direction the farmer would take when responding to an event and whether they would be more reluctant to modify or change the system they have always had. This could be an area that would merit additional investigation. As new and more effective mitigations are always being sought after, research that is based around the possibility of water storage in the region would also be an opportunity for further study.
7 References


Statistics NZ (2012). "Agricultural Production Statistics: June 2012 (final)." Retrieved 18/12, 2015, from


8 Appendices

8.1 Appendix 1: Ethics Permission

TITLE OF PROJECT

CONSENT FORM FOR

PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary;

2. I am free to withdraw from the project at any time without any disadvantage;

3. Personal identifying information [specify e.g. video-tapes/audio-tapes etc.] will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;

4. This project involves an open-questioning technique. The general line of questioning includes Drought response in the Grey Valley. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind.

5. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I agree to take part in this project.

............................................................................
(Signature of participant)

............................................................................
(Date)

............................................................................
(Printed Name)
8.2 Appendix 2: Interview Questions

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the Aim of the Project?

The objective of this project is to have answered a set of questions that will give an indication of how farmers, industry members and local/national government would respond to an increased frequency of drought events in the Grey Valley. These questions will ultimately extract information regarding the attitude and awareness of these parties to the issues surrounding drought and how they might respond to the potential of increased drought events in the future. The project will involve each participant being presented with 5 questions regarding their approach to drought response and will take place wherever is most convenient for each individual participant. This information is being collected to complete a Masters research project by a University of Otago student and will only be used for the purpose of this project.

What Types of Participants are being sought?
Farmers operating dairy farms situated on both sides of the Grey River in the Grey Valley between Greymouth and Mawheraiti will be interviewed during the summer period from December 2014 to April 201. Farmers will be chosen to represent this area according to herd/farm size and to represent the lower, mid and upper of the sections of the Grey Valley. The sampling methods are subjective to the number of farmers available and willing to participate. Ideally each section will be represented by three small farms (≤ 300 cows), three medium farms (301-500 cows) and three large farms (500 + cows). The range of farmers will also be considered, with age of the owner and the time the farm has been established being included.

The interviewee from each farm will be visited twice, once for introduction purposes and to be given the questions and secondly to undergo the final interview. The first visit will consist of an introduction to the interviewer, the questions and some information regarding the project and how the final interview will work, including the aspect of recording the interview. The members of the farm that will be appropriate to interview and give the appropriate information will be either be the owner but if that is not possible, the farm manager/share milker, with the same person being addressed during both visits. Each farmer will be given a discussed period of time between receiving the questionnaire sheet and being interviewed. Measures will be taken to ensure that the interviews and the use of the information will be appropriate and will comply with the regulations outlined by the University of Otago human ethics committee as will every interview done in this study. Each interview will be recorded for scribing purposes and consent from each interviewee will be ensured. The information gathered at each interview will be only be used for the purposes of the project and will not be revealed to any other party without the explicit permission of the interviewee and owner of each individual farm. Any actions taken at each farm will be communicated through to the owner regardless of who is being interviewed and the involved persons will be asked whether they would like to remain anonymous. The interviewing technique that will be used will be a semi – structured open-ended interview conducted face to face.
What will Participants be asked to do?

Should you agree to take part in this project, you will be asked to...

Answer a series of questions regarding the impact of the 2013 drought and how the participant responded to that drought specifically and how they would respond to drought events in the future. Questions regarding the level of assistance of industry and local government will also be included.

Each participant has the full right to remain anonymous and will be given the option to restrict the use of personal information (name, age etc.) or can give consent to allow this information to be published in the projects resulting thesis report.

Please be aware that you may decide not to take part in the project without any disadvantage to yourself.

What Data or Information will be collected and what use will be made of it?

Each interview carried out will be recorded (audio) for scribing purposes and each recording will be securely stored until the completion of the resulting thesis and then destroyed. The raw information will be processed to indicate the response strategies of farmers in the grey valley and specific individual information will only be used with your explicit consent. Staff members of the Otago University Geography Department will access the data. The data will be stored electronically in the form as written documents and audio files. The written data will be included in the final write up while the audio files will be destroyed once fully transcribed.

The data collected will be securely stored in such a way that only those mentioned below will be able to gain access to it. Data obtained as a result of the research will be retained for at least 5 years [or at least 10 years for health research] in secure storage. Any personal information held on the participants [such as contact details, audio or video tapes, after they have been transcribed etc.,] may be destroyed at the completion of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely.
The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

Due to the nature of the research whereby ...(give reasons why anonymity cannot or will not be preserved) it will not be possible/desirable (choose one) for your anonymity to be preserved in the completed research.

On the Consent Form you will be given options regarding your anonymity. Please be aware that should you wish we will make every attempt to preserve your anonymity. However, with your consent, there are some cases where it would be preferable to attribute contributions made to individual participants. It is absolutely up to you which of these options you prefer. The information gathered in this project will be given back to those who have participated in the interviewing process.

This project involves an open-questioning technique. The general line of questioning includes themes associated with drought response specifically in the Grey Valley. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the Department of Geography is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s).
Responses of Dairy Farmers, Industry and Local Government to Drought Events in the Grey Valley, West Coast

The aim of this project is to determine the response strategies of the dairy farmers in the Grey Valley to drought conditions. In order to achieve this, a few chosen farmers will take part in an interview investigating how they have responded to drought in the past and how they would do so in the future. The information gathered during this project will not only achieve the initial aim, but will provide farmers, industry and local government with details of the direction that farmers will take if drought scenarios were to become more frequent and severe.

Questions to be asked during final interview

- What were the impacts of drought on farmers considering financials, stock welfare and ability to farm?

- Did the severity of previous drought events have an accumulative effect on farms within the Grey Valley?

- What strategies do farmers put in place in order to mitigate the adverse effects of a drought event in the Grey Valley?

- What strategies does the industry put in place in order to mitigate the adverse effects of a drought event in the Grey Valley?

- What strategies do local regional government put in place in order to mitigate the adverse effects of drought?