Is a more holistic approach to risk management and risk identification needed on Canterbury dairy farms?

Kellogg Rural Leadership Programme

Course 51 - 2024

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I wish to thank the Kellogg Rural Leadership Programme Investing Partners
for their continued support.

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2 Executive Summary

This report examines risk management practices on Canterbury dairy farms and explores whether there is a need for the development of an Enterprise Risk Management (ERM) framework specific to the dairy sector.

The report also identifies the supply of diesel to farms as critical to ensuring business continuity after an adverse weather event or seismic natural disaster. It studies the likelihood of an earthquake on the Alpine Fault on New Zealand's South Island, or a tsunami caused by a rupture in the Hikurangi subduction zone off the east coast of the North Island. The report also considers the supply of diesel in New Zealand and looks at a number of factors that might disrupt the diesel supply chain.

2.1 Key Findings:

1. Dairy farms in Canterbury are heavily reliant on diesel generators for electricity backup, with most farms having at best a month's supply of diesel to maintain operations.
2. The likelihood of a significant earthquake (M8+ or more) at the southwestern end of the Alpine Fault is statistically relevant with one researcher estimating the probability of a rupture of this magnitude within the next fifty years at approximately thirty percent. In this circumstance, Canterbury's roading and transport infrastructure is likely to be significantly compromised.
3. Similarly, Canterbury's ports are susceptible to both near source tsunami and distant source tsunami potentially damaging fuel import terminals at Lyttelton and Timaru.
4. The COVID-19 pandemic and incidents like the Suez Canal blockage have highlighted vulnerabilities in international supply chains, leading to increased costs and delays for New Zealand.
5. The closure of the Marsden Point oil refinery in 2022 has reduced New Zealand's flexibility in fuel supply and increased its vulnerability to supply chain disruptions and global security threats.
6. The lack of a merchant navy reserve leaves New Zealand exposed to supply chain disruptions caused by geopolitical events, such as the escalation of tensions between China and the United States over Taiwan into an all-out war in the South China Sea. Currently over ninety percent of New Zealand's fuel supply comes from refineries in Singapore, South Korea and Japan. In the case of war, supply from all Asian refineries is likely to be affected.
7. It was found during a series of interviews, that farmers don't generally have a holistic risk identification and management process in place.
8. Developing an easy-to-use risk management framework tailored to the dairy industry could help farmers better prepare for adverse events, increase resilience, and potentially identify new business opportunities.
9. Reinsurance for certain insurance premium categories, such as earthquake damage, could potentially become harder to obtain, posing a potential existential threat to dairy farms if they sustain significant damage and are unable to claim insurance.

2.2 Recommendations:

1) On farm – for farmers regular refilling of the diesel tank is important. Most farmers are on a regular fuel distribution route managed by their fuel supply company. Remote monitoring might also be an option for farmers who use a lot of diesel and need more regular topping up.
2) On farm- where the well for stock water is close to the dairy shed, the pump could be run from the same electricity mains switchboard as the dairy shed to minimise the need to have a second generator to run a stock-water pump.
3) Generation technology – farmers looking at their back-up electricity supply options could look at new generation technologies, such as PV solar and batteries, which are becoming more affordable and provide the farm with a layer of generation capacity that doesn't rely on off-farm inputs such as diesel.
4) AF8 and SAFER – given the high probability of a significant rupture of the Alpine Fault, it would be prudent for the New Zealand Government and local councils to continue its research and

preparedness training alongside local councils and other relevant statutory bodies. Possibly, Tsunami should also be taken into account during these planning and training exercises.

5) ERM research – there is need for further research into the topic of risk management on farm, and the need for the development of an ERM framework for dairy farms and potentially the wider farming community.
6) Diesel supply chain – the government and fuel companies might consider diversifying the source of New Zealand's fuel supplies to include refineries in parts of the world, outside Asia.
7) Merchant Navy – it is likely that the New Zealand Government is aware of, and already working towards finding a solution to New Zealand's lack of a Merchant Navy. If not, it should consider how it might work with allied nations, such as Australia, to mitigate the significant strategic weakness that both countries appear to have.

3 Acknowledgements

I would like to thank the people I interviewed and spoke to while compiling this report. They were all very open and generous with their time and knowledge. This project would not have been possible without their support.

Thanks must also be extended to the whole Kellogg team for putting together a fantastic program. It is clear why the course is so enduring and successful, with alumni found in leadership roles throughout New Zealand's rural community. Thanks to the many guest speakers who informed and challenged us. A special thanks goes to the delivery team of Dr Scott Champion, Dr Patrick Aldwell, Lisa Rodgers, Annie Chant and to their 'team behind the scenes', for making the whole course an experience that I'd certainly recommend to anyone.

To Cohort 50, the *in-situ* course work was a highlight of 2023 for me. I enjoyed meeting you all and the great discussions we had around the tables in class, or over a coffee or beer. While it was a disappointment that I couldn't graduate with you all, I really look forward to continuing our conversations and relationships into the future.

Finally, but most importantly, I would like to thank my family for their support and for picking up the slack and enabling me to complete this course and project during what has been an unexpectedly difficult eighteen months.

4 Introduction

This report looks at risk management on Canterbury dairy farms, how it is currently being applied, and what could be done to improve it. The report then looks in more depth at certain risk scenarios, and the bearing they could have on the susceptibility of the diesel supply chain in Canterbury.

Canterbury dairy farms are heavily reliant on diesel generators as the back-up to their usual grid-based electricity supply. Electricity power's everything within the dairy sheds, as well as pumps for animal drinking water, irrigation and effluent pumping.

A series of interviews was conducted with dairy farmers in the Canterbury region of New Zealand's South Island. Questions were asked regarding each farm's backup electricity supply, diesel supply and also known risks and risk management, particularly with regard to electricity supply issues caused by extreme climatic or seismic situations. All of the farmers initially interviewed fall into the SME category and own and/or manage between one and three farms.

Questions regarding risk quickly revealed that none of the farmers had a formal risk management process in place. All of them had a good understanding of their day-to-day operational risks and had monitoring processes in place for their financial and health, safety and wellbeing (HSW) risks. However, outside of the financial and HSW areas, there were no formal risk identification, documentation or review processes in place. Similarly, none had spent time with their governance or advisory team considering or discussing risks, either on, or off, farm, in any detail.

In light of the realisation that there didn't appear to be a holistic approach to risk management, and that there might be a gap in the business management and/or governance, the focus of the report was widened to look at Enterprise Risk Management, and a further series of interviews was held with a number of risk specialists working within the agri sector.

The report is high level in nature, and while a number of conclusions and recommendations are arrived at, further research is required to fully ascertain whether a formal risk management process is required at an individual farm level.

5 Literature review

5.1 Overview of risk management

Risk management developed as an academic discipline following the second world war and was initially adopted by the insurance and engineering industries to better identify and understand risk (Dionne 2013). However, while its genesis was amongst academia, industry associations and large siloed corporate departments, risk management has evolved into an important tool for any business's management and governance team, to aid them in operational and strategic decision-making (McShane 2017).

Risk management is an important component in ensuring the development of a resilient and sustainable business (Chapman 2011) and can be broken down into four phases; Identification, Analysis, Mitigation and Monitoring. The monitoring phase then provides feedback to the Identification process and informing the Identification phase as new risks are identified or mitigation strategies change.

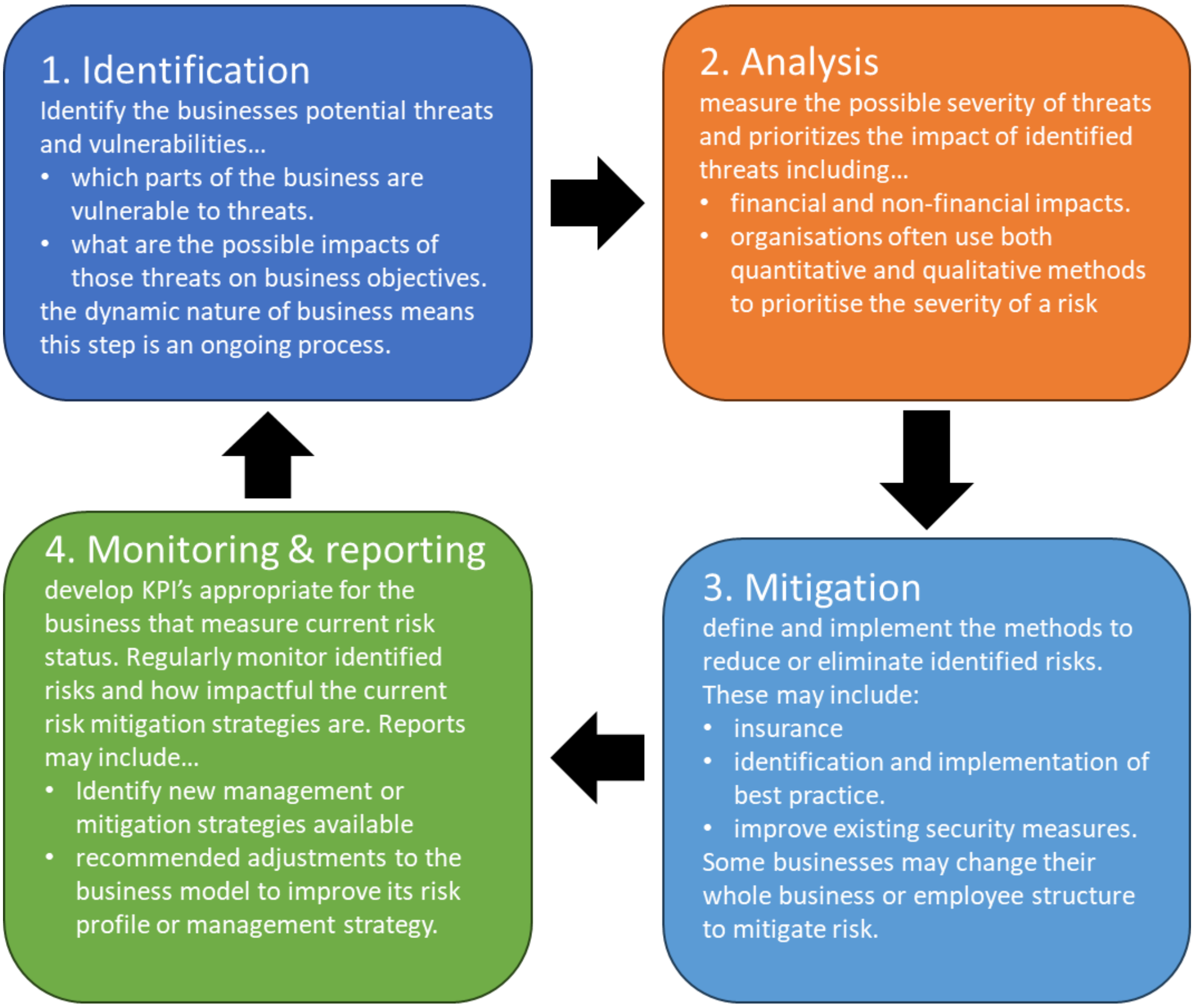

Figure 1 - The four phases of risk management - Identification, Analysis, Mitigation and Monitoring. (Source: McShane 2017, Chapman 2011)

In a project management context, Pritchard (2015) defines risk as the "cumulative effect of the probability of uncertain occurrences that may positively or negatively affect project objectives". Risk has three primary elements, the identified *uncertain occurrence* (often referred to as a hazard), the *probability* (likelihood) it will occur and the *severity* (impact) if the uncertain occurrence eventuates.

Probability / Impact	Low probability (1)	Moderate probability (2)	High probability (3)
Low impact (1)	Low probability, low impact (1x1=1)	Moderate probability, low impact (2x1=2)	High probability, low impact (3x1=3)
Moderate impact (3)	Low probability, moderate impact (1x3=3)	Moderate probability, moderate impact (2x3=6)	High probability, moderate impact (3x3=9)
High impact (6)	Low probability, high impact (1x6=6)	Moderate probability, high impact (2x6=12)	High probability, high impact (3x6=18)

Figure 2 The standard Probability/Impact risk matrix, often used to ascribe a value to each risk. (Source: Pritchard 2015)

Using risk models during risk analysis, similar to that in figure 2, enables the development of an over-all risk ranking. Thus different risks can be compared and ranked. It also supports other comparative analyses for project prioritization, contingency planning and funding support, or basic go/no-go decision making (Pritchard 2015). Other risk qualification practices include what-if analysis, expert interviews and the use of analogies and comparison to similar past events.

5.2 Enterprise risk management

Enterprise risk management (ERM) has its roots in the traditional risk management (TRM) approach, which is focused on managing risks in silos. ERM proposes the integrated management of all risks facing a business, as well as the alignment of risk management with governance and the business's overall strategy (McShane 2017).

Recent years have seen the rise of ERM, typically involving the identification of particular events or circumstances relevant to a business's objectives and assessing them in terms of likelihood and magnitude of impact, determining a response strategy and monitoring progress (NZIOD 2021).

Various methods and frameworks have been developed to help businesses identify and analyse risks within their businesses including COSO and ISO31000 (Ali et al 2023, McShane 2017) and there is evidence to suggest that businesses that develop a strong risk management culture also increase the business's resilience and ability to maintain continuity when risks materialise (Kimura et al 2019)

5.2.1 ERM Frameworks

The need for a more integrated and comprehensive approach to risk management led to the development of ERM frameworks (Farrell & Gallagher, 2015). Two of the most widely recognized ERM frameworks are the COSO framework and the ISO 31000 standard.

The Committee of Sponsoring Organizations of the Treadway Commission (COSO) released its first ERM framework, "Enterprise Risk Management—Integrated Framework," in 2004. This framework was designed to help organizations improve their risk management processes by providing a common language and clear direction for identifying, assessing, and managing risks (COSO, 2004). In 2017, COSO released an updated version of the framework titled "Enterprise Risk Management—Integrating with Strategy and Performance" (COSO, 2017). This update emphasized the importance of aligning ERM with an organization's strategy and performance goals.

The International Organization for Standardization (ISO) introduced the ISO 31000 standard, "Risk Management—Principles and Guidelines," in 2009. This standard provides a set of principles, a framework, and a process for managing risk that can be applied across various industries and types of organizations (ISO, 2009). The standard was revised in 2018 to incorporate feedback from users and to align with other ISO management system standards (ISO, 2018).

5.2.2 ERM Frameworks for SMEs

Small to medium enterprises (SMEs) are often restricted in their access to capital and other resources, potentially making them more vulnerable to external economic shocks. The adoption of ERM may enable a business' management team to prevent or mitigate the effects of such shocks, however ERM risk identification also provides for the identification and recognition of opportunities and allows a business to find innovative solutions and improvements (Pomaza-Ponomarenko et al 2023, Glowka et al 2020). Glowka suggests that one major benefit of ERM is that implicit knowledge within the business is made explicit and that a more complete picture of the overall business arises.

While ERM frameworks have been widely adopted by large corporations, their uptake among SMEs has been slower (Falkner & Hiebl, 2015). This is due to various factors, such as limited resources, lack of expertise, and the perception that ERM is too complex and costly for smaller organizations (Brustbauer, 2016).

SMEs face a wide range of risks that can threaten their survival and growth, such as market risks, financial risks, operational risks, and compliance risks (Verbano & Venturini, 2013). Therefore, there is a growing recognition of the need to adapt ERM frameworks and tools to the specific needs and constraints of SMEs.

5.2.3 Barriers to ERM adoption among SME's

However, some researchers point out there are a number of factors that appear to be inhibiting the uptake of ERM amongst SME's.

Sorin & Afloarei (2020) propose that the hands-on management style in SMEs can deter ERM adoption, with SME owner-managers often choosing to rely on their own skills and experience to manage risks rather than dedicating time and resources to formal ERM programs. Sorin & Afloarei (2020) add that there is often a lack of regulatory imperatives or requirements for SMEs to implement formal risk management programs.

Similarly, Poon et al. (2022) suggest that a lack of familiarity and expertise with risk management principles and strategies amongst SME owners and managers might also be a hinderance in the implementation of ERM and requires specific knowledge and skills that SMEs often lack. Poon et al. (2022) also point out that a perception of high costs of implementation might be a significant barrier for resource-constrained small businesses.

Overcoming these inhibiting factors will be important to increasing ERM uptake amongst SMEs.

5.2.4 Improving ERM frameworks and tools for SMEs to increase uptake

Several researchers and organizations have proposed modified ERM frameworks for SMEs. For example, Smit (2012) suggested a simplified four-step risk management process for SMEs, consisting of risk identification, risk analysis, risk treatment, and risk monitoring. Naude and Chiweshe (2017) developed a simplified operational risk management framework for SMEs that focuses on these factors in their operations.

To improve the uptake of ERM among SMEs, it is essential to address the barriers and challenges they face in implementing these frameworks and tools.

6 Risks that threaten the diesel supply chain in Canterbury

The following series of risks have been identified as having the potential to create significant issues for the supply of diesel to Canterbury dairy farms. This is not intended as an exhaustive list of risks, but merely an illustrative grouping of major risks that might affect the supply chain.

6.1 Seismic risk

6.1.1 Earthquakes

The earthquakes that struck the Canterbury region on September 4, 2010, and February 22, 2011, caused widespread damage across Christchurch and Canterbury, killing 185 people, causing tens of billions of dollars' worth of damage to buildings and infrastructure and creating significant and ongoing health, social and cultural challenges for the people of Christchurch and the wider Canterbury region to overcome (Kongar et al, 2017).

While the Canterbury Earthquakes were generated from the Greendale (GNS Science 2023a) and Port Hills Faults (GNS Science 2023b) beneath the Canterbury Plains, the region is also susceptible to earthquakes generated within any part of the latticework of active fault systems running up the South Island and an active underwater subduction zone at each end of the island (Wallace et al (2018), Hayes and Furlong (2010), Wallace et al (2010)). Of these, the most notable on-land fault line is the Alpine Fault on the western side of the Southern Alps (see figure 3. below).

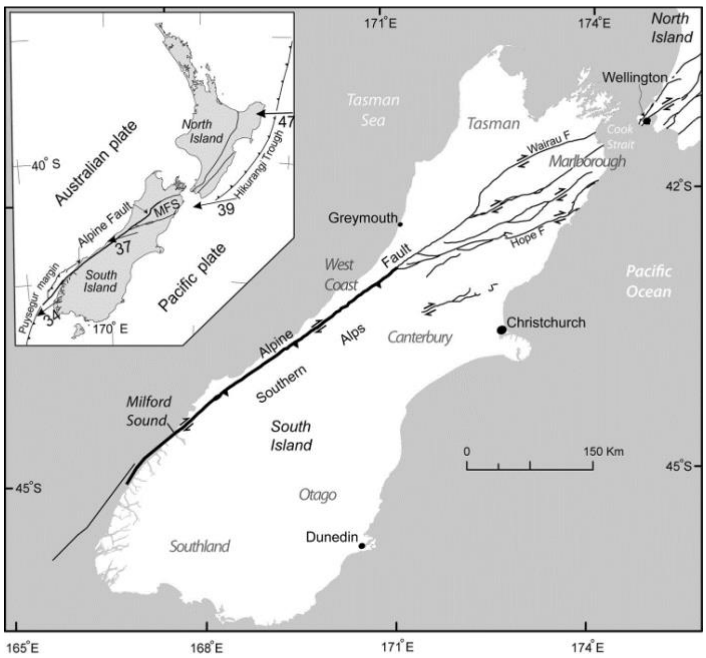

Figure 3 – The South Island's major active faults focusing on the Alpine Fault and its continuation Northeast as the Marlborough Fault System and Wairau Fault. (source: Orchiston et al 2018)

6.1.1.1 The Alpine Fault

Destructive earthquakes often occur on continental plate boundary faults and are generated by ruptures that can span hundreds of kilometres (Howarth et al 2014). The Alpine Fault is one such fault line and represents a major element of seismic hazard in the South Island (Stirling et al. 1998).

The Alpine Fault's long paleo seismic record of more than eight thousand years suggests that the fault has a significant rupture (greater than M_w8) event approximately every 300 years. The last rupture of the southwest section of the fault was in approximately 1717 AD. suggesting that the fault is likely to rupture at some stage in the not-too-distant future (Howarth et al 2014, Cochran et al 2017). Howarth et al (2018) have gone on to propose there is a 29% likelihood of a rupture at the Southwest end of the fault, measuring greater than M_w8, within the next 50 years.

6.1.1.2 The Wairarapa Fault and the Hikurangi subduction zone

The recent $M_w7.8$ Kaikoura Earthquake that struck on the 14th of November 2016 caused a significant rupture of a number of faults at the southern end of the Hikurangi subduction zone. Including the Kekerengu, Hundalee, Hope and Humps Faults.

The last earthquake of a similar size to strike the southern end of the Hikurangi Subduction Zone was the $M_w8.2$ (estimated) Wairarapa earthquake which occurred on the 23rd of January 1855, causing uplift of up to 2.3m in some places near the coast in the Southern Wairarapa. This event produced large surface rupture along the Wairarapa fault and tsunami runup of 9.1m on the eastern side of Wellington harbour (Grapes and Downes 1997).

Recent investigation and modelling of the Wairarapa fault zone, using Lidar-based techniques, suggests there have been at least seven prior earthquake events of a similar size (M_w8 or above) that ruptured the entire Wairarapa Fault zone. The modelling also suggests that the Wairarapa Fault is linked closely to the Awatere, Needles and Kekerengu Faults with recent research (Manighetti et al, 2020) positing that the Wairarapa Fault may be being 'loaded' by seismic events occurring on the faults to the south citing the 1848 Awatere earthquake as potentially loading the Wairarapa Fault for the quake in 1855 and several prior (pre-historic) earthquakes on the Kekerengu Fault were closely followed by quakes on the Wairarapa Fault. That being the case, it is possible that the Wairarapa Fault was loaded by the 2016 Kaikoura earthquake and is now primed to rupture at any stage.

6.1.2 Tsunami

6.1.2.1 Subduction earthquakes and tsunamis

A subduction earthquake is caused by the sudden slippage between two tectonic plates at a subduction zone, where one plate is pushed under another plate. As the subducting plate moves downwards, stress builds up over decades, or potentially centuries as the plates become stuck together and locked. Eventually the stress overwhelms the frictional forces which causes the subducting plate to suddenly slip underwater generating an earthquake and upward transfer of energy to the seafloor. The slip causes the displacement of water, creating tsunami waves.

Tsunami generated by subduction earthquakes can be particularly destructive due to the large vertical seafloor displacement over a wide area, allowing significant water volumes to be displaced. Subduction earthquakes are megathrust earthquakes and are capable of magnitudes M9+. This is because the fault surface area involved is often very large. Significant subduction zones are found offshore from Japan, the Aleutian islands, the Cascadia zone off the Pacific Northwest and down the coast of Peru and Chile.

The $M_w9.1$ Indian Ocean earthquake and tsunami off the coast of Indonesia on December 26, 2004 saw the loss of life in the hundreds of thousands (Wallace et al 2009,) and the M_w9 Great East Japan tsunami in 2011 (Makinoshima et al 2023), with more than twenty thousand lives lost (Frazer et al 2013), were devastating events that were both caused by subduction mega-thrust events.

6.1.2.2 Local, regional and distant tsunamis

Tsunami can be categorised by the distance from the affected coastline being referred to.

- ***Local source tsunamis*** are generated relatively close to the affected coastline, often within the same continental margin region. They tend to be less than 100-200 km and waves generated by the quake take less than one hour travel time to reach the affected coast.
- ***Regional source tsunamis*** are in the 100s to 1000s of km away, with a travel time of 1 to 3 hours.
- ***Distant source tsunamis*** come from sources located upwards of 1000km away and take more than 3 hours to reach the affected shoreline.

Of the 80+ tsunamis on the historical record (post 1835) to have affected New Zealand, 28 are known to have come from local sources, 12 from regional sources and 27 from distant sources (GNS Science 2013)

6.1.2.3 Tsunami in Canterbury

Canterbury is exposed to tsunami hazards from local, regional, and distant sources (Borrero & Goring (2015), Borrero et al. (2014)). The most significant distant source is off the coast of Peru/Chile, South America. Major local and regional sources include the Hikurangi subduction zone off the North Islands east coast, and the Kermadec trench.

Mueller et al (2019) report that known local crustal faults in the local Canterbury region do not pose a significant tsunami risk. While damaging local source tsunami in Canterbury cannot be ruled out entirely, the probability appears to be relatively low based on current understanding of earthquake sources in the region. The historical record of tsunami in Canterbury is limited and continued research is needed.

Regional tsunami sources, are estimated to cause less extensive impacts than the worst-case distant tsunami from South America. However, larger earthquakes on the Kermadec trench could potentially cause more significant impacts, particularly in the North Island (Mueller et al 2021).

Canterbury's biggest threat from tsunami appears to come from a Distant tsunami originating off the coast of South America. These have the potential to cause extensive inundation and damage along coastal Canterbury, according to modelling performed by GNS Science (GNS Science 2013). The modelling suggests a M_w 9.35 earthquake off the coast of Peru could generate significant tsunami impact on the Canterbury region, with over 6 m wave heights in places. While earthquakes this size are rare, there have been three M9+ earthquakes off the cost of South America in the past 150 years (GNS Science 2013).

Distant tsunami may not be felt in Christchurch, unlike most local and some large regional earthquakes, so evacuation decisions would rely solely on official warnings. New Zealand is a member state of the Pacific Tsunami Warning System (ITIC 2023), set up to give members as much warning time as possible to prepare and evacuate citizens from vulnerable coastal places.

6.2 Climatic risk

Extreme weather events can come at significant economic and social cost. For example, the combined cost of all Category 4 & 5 hurricanes (47 events) to hit the US and Caribbean coastline since 2005 was in excess of $US600 billion (Yang et al, 2022). The damage to critical and lifeline infrastructure including hospitals, oil refineries and electricity networks was immense.

Closer to home, the total economic cost of the weather events in early 2023, the Auckland Floods on 27th of January, 2023 and Cyclone Gabrielle on the 2nd of February, 2023 (Farmers Weekly 2023), is estimated by the New Zealand Treasury to be between $NZ9 billion and $14.5 billion (NZ Treasury, 2023) across all the affected regions, with a significant portion of that being attributed to damaged roading infrastructure. Making it one of New Zealand's costliest natural disasters (Stevenson, 2023). In the Gisborne district alone, more than 140 bridges were damaged by flooding and 8 bridges were destroyed (Gisborne District Council, 2023). Power outages in the Gisborne region left farms without electricity for weeks (Wong & Pullar-Strecker 2023).

6.2.1 Flooding in Canterbury

Not immune to flooding events, the most recent event of significance in Canterbury saw 540mm of rain fall in the headwaters of the Ashburton River near Mt Somers Station over the 72-hour period of 29th to the 31st of May 2021. Further East on the Canterbury Plains, at Hinds, 185mm of rain fell over the same period saturating the soil. Both the Ashburton and Hinds rivers burst their banks flooding farmland and causing major damage to farm fencing infrastructure as well as the stop bank and flood management infrastructure. The Ashburton bridge across SH1 was damaged and forced to close for several days (Ashburton District Council 2021).

6.2.2 Wind and snow storms

Canterbury is also susceptible to severe snow events. The 'big snow' on 28 August 1992 is the most significant in living memory. While Christchurch received more than 30cm of snow and flooding in parts of the city, it was the rural community that was hardest hit with a reported one million sheep and lambs killed, at an estimated cost to farmers of $40 million (King 1992).

Other snowstorms of significance to affect the Canterbury region occurred in 1945, 1967 and one on the 11th of June 2006 which hit South Canterbury particularly hard, causing widespread power outages of up to three weeks and freezing water pipes (Hendrikx 2006, Stilwell 2008).

However, it is possibly the wind that produces the most regular extreme weather events and causes the most damage on an aggregated basis (Safa and KC 2018). These events often occur in late Winter and Spring and can record wind gusts reaching speeds in excess of 180km/hr.

One infamous event in August 1975, during which winds of 115km per hour and peak gusts of around 170km per hour were recorded at Christchurch Airport, caused forest damage equivalent to 2.2 million cubic metres of roundwood (Wilson 1975). Another event on October 15 1988, in which wind speeds reached 140km/hr, saw thousands of tons of topsoil blow out to sea, hundreds of hectares of crops destroyed and arcing power lines started many fires. A couple of large power pylons were toppled (Brenstrum 2023).

During an event on the 10 September 2013 an estimated 800 centre pivot irrigators were damaged (Safa and KC (2018), Benny (2014)), with many flipped upside down, the resulting damage taking months to repair and costing millions of dollars in insurance claims.

And, most recently, an event in North Canterbury on October 14 2023 (RNZ 2023), recorded wind gusts between 150 and 200 kilometers per hour and saw many trees in the region uprooted and the electricity network down for nearly a week in some parts of the district.

6.3 Geo-politics and supply chain risk

Risk is also inherent in managing the supply chain and access to markets. In recent years, many companies have outsourced non-core business activities to offshore manufacturing facilities, often focussing on their core competencies of design and marketing as a way to compete on global markets (Nof 2013). Thus, very few companies act entirely independently, with most acting as part of a globally connected supply network, reliant on others to supply critical parts, ingredients or services to keep the business going.

During a natural disaster, damage to critical infrastructure such as fuel supply pipelines, roading and rail networks and port and fuel terminals can cause critical failures in the diesel supply chain across multiple levels, as was the case after Hurricane Irma in Florida in 2017 (Florida DOT, 2018) and to a lesser extent the Christchurch Earthquake in 2011 (RNZ, 2011).

Yang et al (2022) found the diesel fuel supply chain (DFSC) is critical to multiple aspects of disaster relief (in that particular case focussed on hurricane relief in the United States), pointing out that transportation networks rely on the DFSC to provide fuel for vehicles used for evacuation and repair and critical infrastructure, such as hospitals, urban water supplies and facilities for first responders all require diesel for power generation when electricity is lost.

6.3.1 Supply chain disruption caused by Covid-19

Covid-19 caused considerable disruption to international supply chains (Nikookar & Yanadori 2022) and demonstrated their importance. The shipping industry and container ports were both exposed, with port congestion into the West Coast of the United States particularly problematic, caused by workforce shortages at the ports. Repositioning empty containers back to Asia for reuse, or indeed getting them across borders also became an issue as cross border restrictions implemented to reduce the transmission of the virus took effect. Compounding this was an increase in imported goods caused by the US Government stimulus package and, due to the lack of containers available, a huge increase in the per container shipping costs as can be seen in Fig.4 where the average cost of a 40-foot container (FEU) quadrupled (UNCTAD 2023, Youd 2023).

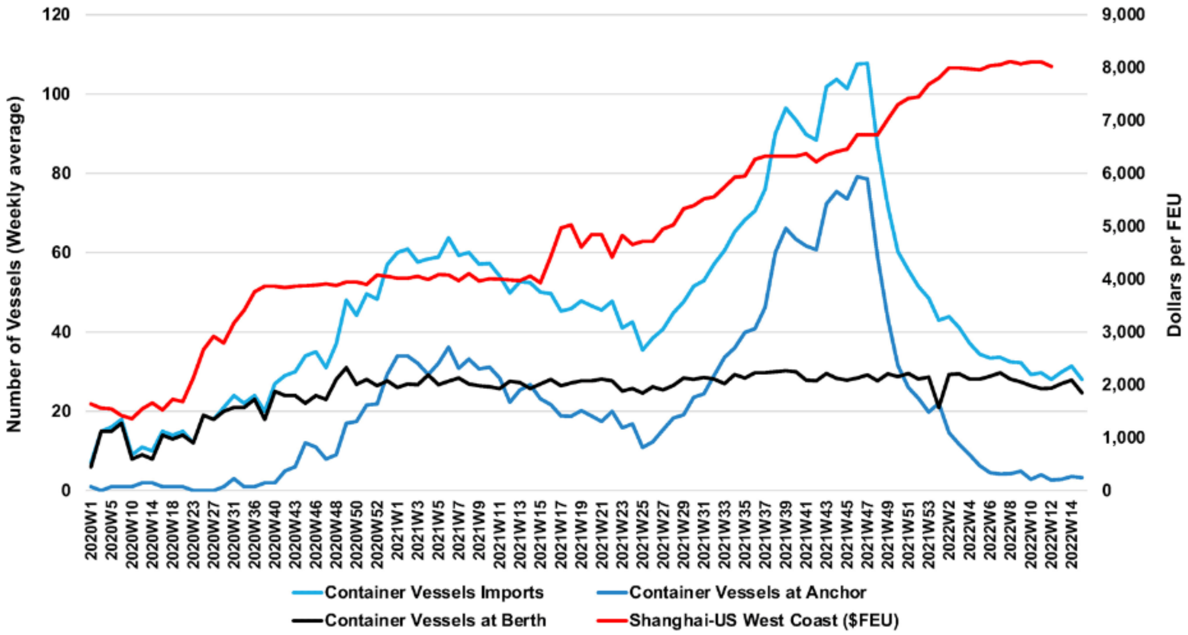

Figure 4 - Source: Marine Exchange of Southern California.

Shipping and freight congestion led to increases in the cost of many raw materials, as they became hard to procure, as well as distribution and warehousing as goods sat in transition for longer. The increased costs and lengthened supply lines affected not only the US but also most of the Asia-Pacific region and beyond (Theo et al 2001, Li et al 2023). New Zealand also experienced significant delays and congestion (Shaw 2023), as well as a reduction of shipping services which is only now getting back to normal.

6.3.2 Supply chain disruption in the Suez Canal

Disruption to regular shipping services have been highlighted in the past five years by several incidents in the Suez Canal which until recently facilitated an estimated 12% of the world trade at an approximate daily value of US$9.6 billion (Harper 2021).

In March 2021 the canal was inadvertent blocked by the Taiwanese container ship the *Ever Given* (Graves et al 2022, Freightplus 2021). The ship took six days to move and enable clear passage, causing significant disruption to international shipping timetables at the time.

More recently, shipping passing through the Red Sea, at the southern end of the canal, has become a target for drone strikes by Houthi rebels. Many logistics and shipping firms are now rerouting their cargoes around the Cape of Good Hope, causing longer shipping times and incurring higher costs for customers (Edser 2023).

6.3.3 New Zealand's fuel supply

Until the Closure of the Marsden Point oil refinery in 2022, approximately 70% of New Zealand's fuel was refined from imported crude oil, with the balance imported from Asia as refined product (MBIE 2023). In mid-2021, Refining NZ Ltd, the refinery's owner, made the decision to close the Marsden Point oil refinery near Whangarei. The closure took place in April 2022 and the facility is now a fuel storage terminal, importing, storing, testing and distributing transport fuels to the upper North Island.

The closure of the refinery removed New Zealand's flexibility to import crude oil from anywhere and refine for the fuels we specifically need. It also removed the ability to re-refine tainted and off-specification fuel stocks. These now have to be sent to be re-refined offshore potentially creating short term supply issues, such as happened to a recent batch of aviation fuel (Terry 2022).

The Maritime Union of New Zealand (MUNZ 2022) believe the closure has left New Zealand exposed to supply chain disruptions, such as we saw with Covid-19, as well as new and looming global security threats such as the Russia-Ukraine war and growing tensions between the United States and China over Taiwan.

Advice to the Hon. Megan Woods, Minister of Energy during the period leading up to the closure of the refinery, suggests that much of New Zealand's fuel supply has been imported and delivered directly from offshore sources for several decades and that the refinery was only supplying fuel for the upper North Island (Corbett 2022).

In mid-2022 the Governments announced a new policy package to improve fuel resilience, requiring those licensed fuel importers with access to bulk storage facilities to increase their minimum average storage capacity to 28 days use for petrol, 24 days for jet fuel and 21 days for diesel. The government will also mandatorily hold 7 days of diesel separately, having recognised that diesel has a critical role in running critical services and infrastructure, and transporting food, during an emergency. These measures were put into place through the passing of the Fuel Industry (Improving Fuel Resilience) Amendment Act (2003) in August 2023 and will take effect from July 2024 (MBIE 2023).

6.3.4 Geopolitics

The Maritime Union's call isn't without some foundation, however. The escalation of hostilities between Russia and Ukraine into open warfare on the 24th of February 2022 saw a spike in world oil prices (see Fig.5) and continued volatility since.

Figure 5 - Brent Crude oil price – USD/barrel. (Source: marketwatch.com)

War and other geopolitical supply chain disruptions not only increase the price and constrict the supply of fuel. They can have an effect on many different goods and commodities. Figure 6 below illustrates the increase in the international price of wheat after the war escalated. Both Ukraine and Russia are top ten producers at 85 million and 25 million tons respectively (Datapandas.com 2023).

Figure 6 - Chicago SRW Wheat Futures - USD/unit. (Source: Google Finance) (NOTE: 1 unit = 50 tonnes or 5000 bushels)

Russia's invasion of Ukraine in February 2022 created challenges for China's interests and priorities. China has been quite supportive of Russia, echoing Russian talking points blaming NATO expansion for the conflict. The conflict has strained relations between China and Europe, while galvanising the European peoples support for NATO (Ivanov 2023).

Meanwhile Chinese aggression toward Taiwan has increased, as demonstrated by the Chinese military exercises held in the Taiwan Strait in early August 2022 following the visit of Nancy Pelosi, Speaker of the US House of Congress, and by increasingly provocative statements made by Chinese President Xi Jinping, requesting (requiring) the People's Liberation Army's (Chinese Military) readiness to invade Taiwan by 2027 (Sachs 2023, Yen 2023).

In February 2023 the United States announced plans to build four new naval bases in the Philippines' northernmost Luzon province, in an effort to counter China's growing naval presence in the South China Sea and give it a strategic position near Taiwan (Dress 2023).

6.3.4.1 The declining Merchant Navy

Merchant Navy (also called the Merchant Marine) is the term used to describe the fleet of shipping vessels registered by a specific country (Wikipedia 2024). In a recent podcast, Anderson et al (2024) discuss the decline of the merchant shipping fleet owned and controlled by many of New Zealand's western allies.

During both World Wars the merchant navy was crucial to keeping supply lines open to the United Kingdom and it was more recently called upon to support the British war effort during the Falklands War in 1982 (IWM 2024).

Until recently, trading nations such as New Zealand and Australia maintained a merchant shipping fleet that could be called upon (requisitioned under an agreed charter with their respective government) to enter into direct service, carrying goods (or in some cases soldiers or refugees) for the government. However, currently neither New Zealand or Australia have any ships of consequence on their shipping registers and are totally reliant on international shipping companies and contracted vessels and crews to fulfil supply chain requirements.

Court (2023) suggests that during times of peace this is a perfectly fine arrangement. However, during times of conflict (and to a lesser extent periods of natural disaster), merchant fleets become critical to the supply of raw materials, including fuels, fertilizers, medicines and many consumables to island trading nations. He goes on to point out, with regard to Australia, "China performs the largest component of our sea trade, despite being unquestionably our biggest potential adversary".

Ninety nine percent of Australia's trade is carried by ship (Dunley 2024) and similarly high percentage is likely to apply to New Zealand. As Court (2023) points out, much of this trade is with a potentially significant military adversary. This would appear to leave both New Zealand and Australia vulnerable to significant supply chain disruptions, if war were to break out in the Taiwan Strait and wider South China Sea region.

7 Methodology

7.1 Literature review

A literature review was conducted into risk management and ERM, as well as several specific areas of risk that may be pertinent to dairy farms in the Canterbury region, including seismic risks and supply chain risks.

7.2 Web search

A web search was conducted to identify what online risk management resources are available to farmers from New Zealand based banks, insurance companies and accounting firms and generally. This was not exhaustive in nature but did identify that there is nothing in the way of a suitable ERM framework for small businesses to use if they want to develop their own risk management systems.

7.3 Interviews

Interviews were carried out with seven farmer representatives. Six were farm owners with between one and three farms owned. The seventh farmer representative had recently been a senior manager within one of the larger corporate farming entities in the Canterbury region and now works within one of the milk processing co-ops. He bought an insight into both of these important parts of the dairy industry. Brief farmer profiles can be found in Appendix 1.

Interviews were also carried out with professionals providing support services to dairy farmers and the dairy industry in Canterbury. Brief profiles of the professionals interviewed can be found in Appendix 2.

7.4 Thematic analysis

Interviews were analysed using thematic analysis, a method for identifying, analysing, and reporting patterns within qualitative datasets (Braun & Clarke, 2006). Following the thematic analysis process, mind maps were developed to show the high-level themes arising from the interviews.

A total of 13 semi-structured interviews were held, 7 with dairy farmers and 6 with wider stakeholders including management level representatives of a petroleum-based energy company, accountant, banker and several from the insurance industry.

Anonymity has been preserved by referring to each participant by the generic classification of ***participant***. Interviews were conducted either via Microsoft Teams or in-person. They typically took between thirty minutes and one hour each.

7.5 Use of Artificial Intelligence (AI)

The claude.ai/ and otter.ai/ platforms we used in the development of this report, including to:

- summarise academic articles.
- record and transcribe interviews.
- assist with identifying themes amongst interviewees.

8 Limitations

- Given the breadth of the agricultural sector and the topic of risk management, the scope of this report has been narrowed to focus on risks that might affect SME dairy farming operations in the Canterbury region of New Zealand. However, it has identified this topic as an area that would justify further investigation. It is likely that some of the findings can be extrapolated across other regions and industries within New Zealand's food and fibre and sectors.
- The project has focussed in on several areas of risk that the author considers to be most pertinent to the topic. Specific risks that are likely to stop the supply of diesel to the farm gate for a prolonged period of time.
- The findings attempt to highlight interesting or insightful comments made by participants. These findings are merely indicative, given the small sample size. However, they provided some insight into the risk management and diesel supply management systems among the farmers interviewed.
- Where comments from participants have been included, they have been refined to improve readability in the report and therefore may not be quoted verbatim. Several of the farmer participants were known to the interviewer prior to the interview, others were referred. They were all speaking in their capacity as the farmer/business owner and were not representing the co-operative or company they supply to.
- Likewise, those industry stakeholders interviewed, while giving their views freely, were not necessarily giving the views of the companies or organisations they represent or work for.

9 Analysis and Results

9.1 Internet search

An internet search was conducted, to ascertain what free resources are available online to farmers to help them develop a risk management system or framework for themselves. There are a lot of ERM frameworks offered by consulting firms at a fee. However there don't appear to be any comprehensive resources available from any of the banks, insurance companies or accounting firms.

Given the number of potential companies, this was not an exhaustive search. However, it was instructive that only one of the banks had any risk identification or management resources (see ANZ – risk management plan below) suggesting that there might be an opportunity to develop a series of resource for farmers to access.

9.1.1 HSW software

A web search for HSW management software brings up a plethora of options. Farmers interviewed mentioned a number of HSW software platforms they use to help them identify and manage their HSW obligations on farm. They include:

- Site safe- https://www.sitesafe.org.nz/
- HazardCo- https://www.hazardco.com/nz/other-industries/

As mentioned elsewhere in this report, this is one area of risk management that farmers appear to have a good understanding and grasp of and are generally managing. This might be because the social, and potentially financial, implications of someone having an accident on the farm can be significant.

9.1.2 ANZ- risk management plan

Of the New Zealand based banking websites visited, only the ANZ Bank offered any tools that could be used to help identify and document risks. Their *Risk Management Plan Template* (link below) names and gives a brief and generic description of the main categories of risk.

chttps://www.anz.co.nz/business/bizhub/running-your-business/business-risk-management-and-insurance/managing-risk-in-business/

9.2 Interviews with farmer

The following are the findings of a thematic analysis of the interviews held with farmers. They are generally presented in the order the related questions were asked in the interviews.

9.2.1 Risk register

None of the participants interviewed had a comprehensive risk identification and management system for their business. When asked, they often replied (usually with a smile) "it's up here" pointing to their heads.

When questioned further, they all had a formal process in place around their HSW management. This is generally expected as part of the farm auditing process. All of them have processes in place to identify and report on-farm operational hazards and risks involving their whole team. These usually involve a specialist HSW consultant or an online platform such as *On-Site* or *HazardCo* which provide templates that can be updated as required.

Often through their governance structure or alongside their farm consultants, they also have financial planning and monitoring in place.

With the exception of the corporate farm, outside of the two areas of HSW and Finance there wasn't any formal risk identification or management on any of the farms. The comment '*I only worry about the things I can control*' was made a number of times.

9.2.2 Critical risks to the business

Each of the participants was asked what the (up to 5) critical risks were to their business. All of the farmers had different perception of what the critical risks to their business are and unsurprisingly that appears in part to be driven by their experiences and stage in life. The following themes emerged.

9.2.2.1 Animal welfare and biosecurity

- Animal welfare was a key theme across the participants.
- Concerns around MPI and biosecurity at the boarder were raised with the 2017 outbreak of Mycoplasma Bovis mentioned several times.

9.2.2.2 Employee welfare, health and safety

- One of the common themes was around employee welfare, health and safety.
- All of the respondents recognised the importance of having a happy, well-functioning team. This includes ensuring their accommodation is warm and serviceable during adverse wind and snow events when electricity outages tend to occur.
- All of the participants felt they are on top of health and safety requirements, although several mentioned they are planning to make slight changes to the way they want to manage their health and safety going forward.
- The importance of including the team in the health and safety process and especially in the identification of hazards on-farm was a key topic. '*It's a lot better to identify a hazard and reduce the probability of it happening, than manage the social and financial costs of an accident'*.

9.2.2.3 Extreme weather and natural disasters

- All of the participants were farming at the time of the 2010/2011 Canterbury earthquakes and had come out of that experience relatively unscathed.
- Only one was farming in the Selwyn District (the most affected farming area) during the earthquakes. They learned about the importance of access to a generator to keep milking. They shared one generator between 4 farms, each getting one milking per day done. They had been very lucky to get access to the generator the morning after the quake and had they missed out on getting it, all four farms would probably have had to dry off their herds.
- One of the participants, farming under the Canterbury foothills, commented that he and his team have procedures in place and are prepared for most extremes, given where they are. They expect snow in the winter and high wind (north-westerly) in the spring. It's when they get unseasonal weather such as a late snow in October, that it puts strain on the business and the team.
- All of the participants were aware of the threat the Alpine Fault presents to the Canterbury and wider South Island, particularly the West Coast.
- Tsunami threat wasn't something any of them particularly thought about.
- Two of the farmers, through their involvement in different emergency management roles had insights into different parts of the planning and risk assessment process. Both commented on the bridge infrastructure being of major concern in an earthquake with both bridges across the Rakaia (SH1 and gorge), the Ashburton bridge (SH1) and the Waimakariri Gorge bridge all identified as being of significant concern.

9.2.2.4 Financial stability

- They all have a range of financial KPI's they keep a very close eye on. It was regularly noted that the milk price and payout drives everything on farm. Low payout's put real pressure on some in the industry.
- Most mentioned their concern about their current exposure to interest rates and high inflation, and the effect that was having on farm input costs.

- Several noted they had noticed a bit more pressure from banks to keep on top of debt repayments. However, they also noted that other banks had reached out and were courting business.

9.2.2.5 Stock water

- Ability to maintain supply of stock water was recognised by all as absolutely critical.
- One of the farms had a gravity supply system, one had an independent supply from two pumps and its own backup generator system, and a third was reliant on moving the shed generator across to a separate irrigation well to pump stock water.
- One of the participants involved in emergency management planning expressed real concerns about mid-Canterbury's position vis-à-vis stock water in the event of a severe earthquake destroying deep wells and piping infrastructure. He believes that may prove to be a significant issue if the worst AF8 scenario eventuates.

9.2.2.6 Supply chain

- Supply chain was raised several times by participants concerned about access to critical farm supplies in the case of natural disaster. However, fuel supply wasn't something any had actively considered until raised in the interview. All felt that with a generator to run the dairy shed and diesel in the tank they would be fine although they hadn't considered what a problem with diesel supply might entail.

9.2.2.7 Dairy shed ICP, diesel supply and generators

- All of the sheds had the same general electrical components running off the shed ICP, such as the milking platform and vacuum pump, refrigeration and feed mill etc. The exception was stock water (covered above).
- Nearly all of the participant farms own a generator, to run the dairy shed as back up to the electricity network. The one exception is in the process of purchasing a generator at the moment after experiencing a multi-day electricity outage in October 2023.
- All but one of the participants had at least 4,000L of diesel storage capacity on the farm.
- They were all on a regular program to top up the diesel tank at least monthly, often fortnightly. However, most commented that their diesel supply regularly went well below half of it's total capacity.

9.2.3 Interviews with industry professionals

9.2.3.1 Is there a need for better on farm risk management?

- The answer to this was an unequivocal "YES". All of those interviewed strongly agreed that from their perspective there is a need for better risk identification and risk management within the farming community.

  "I think I'd agree there's a crying need for better risk management in farming" participant

  "We need better understanding and better tools on farm to identify and manage risk … at the moment farmers are pretty good in the finance space and understanding their business risk, partly because that's what their farm consultants focus on…but when you look at climate risk or personnel risk and some of those other areas…it's not so good" participant

9.2.3.2 What ERM frameworks are available to farmers at the moment?

- None of those interviewed are aware of any risk management program or framework in the market that are designed or offered to the SME farming community.
- One of the insurance interviewees said they are in the early stages of developing a framework for their clients. The proposed framework will be scalable for use across different sized clients and flexible to allow for different industry types.

9.2.3.3 The divide between SME's and the corporates

- The interviewees all acknowledge that current risk management practices vary between the SME farming operations and corporate farmers. All the interviewees suggested that they expected the corporate farming groups would have some risk management processes in place. (note: the term ***corporate farmers*** wasn't defined and could include larger family owned farming operations).
- These observations were corroborated in the interview with corporate farming manager.
- one of the insurance interviewees the while the corporate farmers are running a risk management program, often they are only covering the basics, or are very business risk focussed but not necessarily looking at some of the harder to manage risks

"Some of our large corporate farming clients do some risk management…however, they are just coming out of the starting gates in terms of sophistication" participant

9.2.3.4 What does a useful ERM framework look for farmers

- It was mentioned by several that the ISO and COSO frameworks are too cumbersome and costly for SME's to be expected to implement.

"You need to get the balance of risk management right…too much can stall activities (or) scare folk into not being entrepreneurial and have a chilling effect on business growth" participant

"how do you get the risk management tools to them in a way that meets their budget and requirements, so that they're not reinventing the wheel each time, but are getting a fair and relatively comprehensive view of what their risk actually is?" participant

9.2.3.5 Getting insurance will become harder and the cost will go up

- The insurance landscape is expected to change in the next 10 years, with the reinsurance of certain types of policies becoming much harder to secure. Particularly in regions prone to specific natural disasters.

"Looking at trends overseas we're starting to see reinsurers blacklisting certain types of policies within certain jurisdictions…California forest fires, for example, or flooding and inundation in parts of Florida…the United States have a lot more regulatory controls around insurance, however it's quite possible we will see similar measures implemented here for, say, earthquake insurance in Canterbury, or flooding and inundation in many of the country's beachfront communities" participant

9.2.3.6 Technology will play a part in the future of insurance

- One of the insurance interviewees mentioned the use of text messaging to get information out to clients.

"we use text messaging to get information to our clients about things happening in their area, such as a spate of burglaries, or reminders to remove the birds nests from the tractor engine bay in Spring" *participant*

10 Discussion

10.1 Canterbury's infrastructure resilience

Both distant source tsunamis originating from South America, as well as regional tsunami from the Hikurangi subduction zone pose a significant inundation risk to Christchurch and the Canterbury coast (Mueller et al., 2019). Modelling shows distant source tsunamis could cause more inundation than previously thought. The Chatham Rise may channel and Pegasus Bay focus tsunami energy towards Christchurch.

In terms of earthquakes, numerous active faults crisscross the Canterbury region, including the Porters and Amberley faults. The Alpine Fault, which ruptures on average every 300 years generating M_w8+ earthquakes, also threatens Canterbury infrastructure. There is a >25% chance of the next Alpine Fault rupture occurring before 2050.

Key infrastructure vulnerabilities include:

- Many Canterbury bridges are at medium-high risk of earthquake damage, especially over the Rakaia River (NZTA report, year unknown). Flooding could also damage already susceptible bridges, such as the Ashburton bridge on State Highway One.
- The Lyttelton and PrimePort fuel import terminals are vulnerable to tsunami, with modelling showing wave heights could exceed 6m and 4m respectively (Lane et al 2016).
- Roads and highways are susceptible to landslides, rockfalls, liquefaction and inundation from tsunamis and earthquakes (NZTA 2018).

Canterbury infrastructure faces substantial risk from both tsunami and earthquakes originating from various local, regional and distant sources. Ongoing research, modelling, infrastructure upgrade and preparedness planning is required to build resilience.

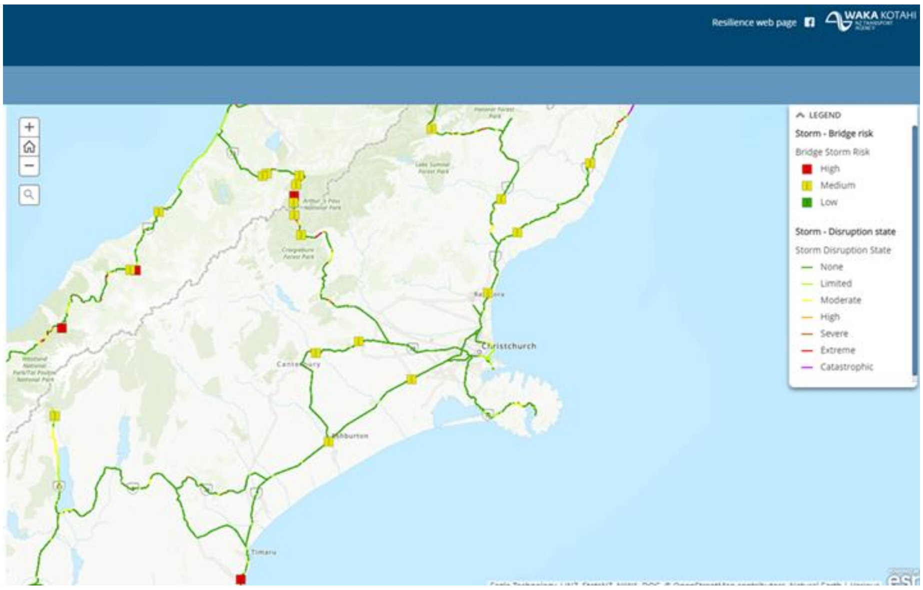

Figure 7 - bridges on NZTA's network within the Canterbury region that are susceptible to storm damage (source NZTE website)

Figure 7 indicates the bridges considered by the New Zealand Transport Agency (NZTA) to be at medium or high risk of damage by storms (flooding). It is notable that the Ashburton River is only at medium risk despite the flooding and damage caused in the 2021 flooding event previously mentioned.

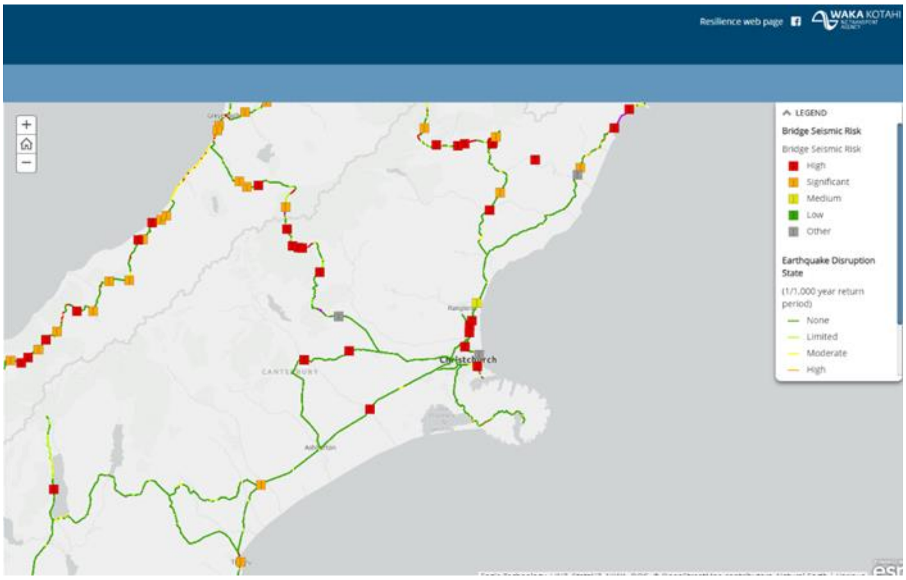

Figure 8 – bridges on NZTA's network within the Canterbury region that are susceptible to earthquake damage (NZTA website)

Figure 8. highlights the vulnerability of Canterbury's roading network in the event of another significant earthquake. Twenty bridges are in the high seismic risk category and a further 10 in the significant risk category, including both bridges across the Rakaia River.

The Waimakariri Gorge bridge is not on the map because it isn't owned or managed by TZTA. However, the Waimakariri Gorge bridge is a major arterial route for logistics companies servicing the agricultural sector. Removal of this bridge from the wider transport network would add a further 100-120 km to any trip, increasing transport costs and causing time delays.

Also of note is the return period provided of 1000 years (circled in red on fig.7). This seems incredibly optimistic. As previously mentioned in this report, the Alpine fault alone has been shown to have an M_w8+ rupture on average every 300 years, with a greater than 25% likelihood of the next happening before 2050. There is also a latticework of faults running beneath the Canterbury Foothills and across the Canterbury Plains including the Porters and Amberley faults.

10.1.1 The susceptibility of Ports of Lyttelton and PrimePort (Timaru) to tsunami

The Port of Lyttelton and PrimePort are home to the two fuel import terminals in Canterbury. Both are vulnerable to tsunami.

Modelling shows that were a M_w9 earthquake to occur on the southern Hikurangi margin, water levels at Lyttelton Port would be likely to exceeded 6 meters with maximum current speeds in excess of 30 knots (Borrero & Goring 2015). Similarly, modelling of a distant source M_w9.35 earthquake and tsunami from off the coast of Chile/Peru indicates wave heights would be on a par with historically observed maxima at Lyttelton, approaching 6 meters (Borrero et al. 2014)

Borrero et al. (2014) points out that the shape of Lyttelton harbour appears to amplify tsunami energy, increasing and thus increasing the observed wave heights in previous known tsunami, compared to subsequent modelling.

At PrimePort in Timaru, Borrero & Goring (2015) report that for a M9.35 earthquake and tsunami from the southern Hikurangi margin, maximum water levels at PrimePort are likely to be around 2 meters. For a distant source M_w9.5 tsunami from coastal Chile/Peru, maximum sea levels are likely to be near 4 meters.

There have been 3 significant ruptures of the southern Hikurangi subduction zone since the mid 1840's (GNS Science 2013), the 1848 Marlborough quake (M_w7.5), the 1855 Wairarapa quake (M_w8.2) and the Kaikoura quake in 2016 (M_w7.8). None of these have reached the M_w 9.5 required to cause significant issues at either port. Of course, that doesn't mean there won't be a quake of M_w9.5+ magnitude, just that there hasn't been one in the recorded history. Certainly, there seems to be capacity for it if Manighetti et al (2020) are correct in their suggestion that the Kaikoura quake may have 'loaded' the Wairarapa fault for another quake to occur.

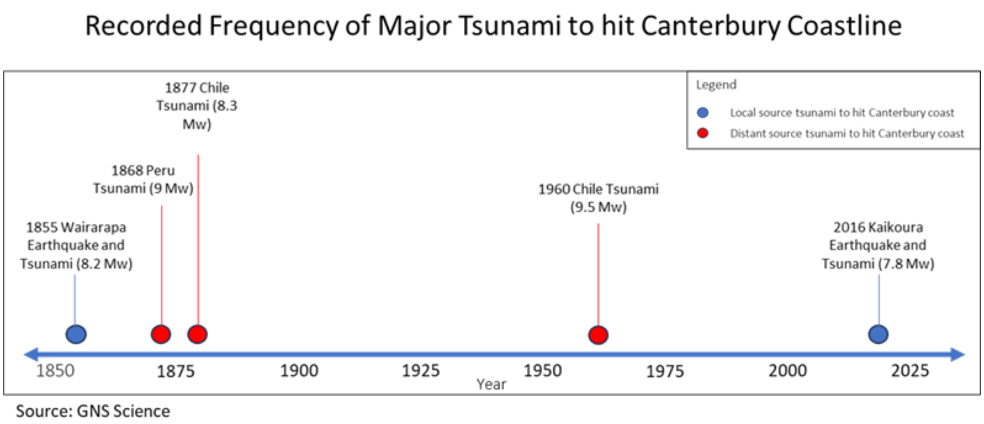

Figure 9 - frequency of significant tsunami to hit Canterbury coastline (source: GNS tsunami database)

A distant source quake and resulting tsunami from South American seems highly plausible. As figure 9 (above) illustrates, the frequency of distant source earthquakes appears to be relatively high with three events in NZ's recorded history, in 1868 (M_w9.1), 1877 (M_W9) and 1960 (M_w9.4-9.6). The 1868 and 1960 events both saw significant damage to boats, shops, wharves, jetties, port facilities, and boatsheds with run-ups of up to 4m recorded down the whole of New Zealand's eastern seaboard. In places, some of the largest waves of the tsunami arrived within an hour or two of low tide, particularly in the lower half of the North Island and northern half of the South Island, dampening the worst of the possible effects.

Based on both modelling and on the record of past events, both ports appear to be highly exposed to both local source tsunami from the southern Hikurangi margin and more particularly distant source tsunami from off the coast of South America.

10.1.2 AF8 and the SAFER plan

Despite the optimistic return periods for earthquakes and tsunami stated on the NZTA website, with the prevalence of significant earthquakes in the South Island during the past decade or so, and the increased statistical likelihood of another seismic related disaster in the next 50 years, the NZ Government has directed Civil Defence and other related agencies to develop a strategy to manage the initial disaster response.

The Alpine Fault Magnitude 8 (AF8) project is a 3-year collaborative effort focused on preparing for a magnitude 8 earthquake on New Zealand's Alpine Fault (Orchiston et al 2018). The project brings together policymakers, practitioners, and researchers to improve response capabilities for a major South Island earthquake.

A key output is the South Island Alpine Fault Earthquake Response (SAFER) plan (Emergency Management Southland 2018), which provides the framework for a coordinated response across South

Island Civil Defence Emergency Management (CDEM) groups and other partner agencies. The SAFER plan outlines concepts, principles and actions to enable effective response coordination across the South Island. It is intended for use by CDEM groups, government agencies, lifeline utilities and other stakeholders involved in response and recovery. The plan sits between regional CDEM group plans and the national CDEM plan. It will be activated immediately when certain earthquake triggers occur and covers the initial 7 days of response. SAFER provides the groundwork for close cooperation that a major Alpine Fault earthquake would require.

10.2 New Zealand's fuel supply

The closure of the Marsden Point oil refinery in April 2022 could have a significant impact on New Zealand's fuel supply at some point in the future. Prior to the closure, around 70% of the country's fuel was refined from imported crude oil at the refinery, while the rest was imported from Asia as refined product. Now 100% of New Zealand's fuel is imported.

Closure of the refinery has removed New Zealand's flexibility to import crude oil from various sources and the ability to re-refine tainted or off-specification fuel stocks locally. This has left the country vulnerable to supply chain disruptions and global security threats.

The government's policy package, requiring licensed fuel importers to increase their minimum average storage capacity addresses general supply-chain issues during times of peace. However, if the geopolitical climate were to escalate, and New Zealand were in some way involved in a war, it is possible to imagine a scenario whereby the regular delivery of fuel became problematic.

10.3 General supply chain disruption

The COVID-19 pandemic caused significant disruption to international supply chains, and highlighted vulnerabilities in the shipping industry and at container ports. Workforce shortages, container repositioning issues, and cross-border restrictions led to port congestion, particularly on the West Coast of the United States. The increased demand for imported goods and a lack of available containers in some cases resulted in a significant increase in the average cost to transport a 40-foot container (FEU). The increased costs and lengthened supply lines affected the Asia-Pacific region, with New Zealand experiencing significant delays, and a reduction in shipping services.

In addition to the pandemic, disruptions to regular shipping services have been highlighted by incidents in the Suez Canal, which facilitates an estimated 12% of world trade. In March 2021, the Taiwanese ship "Ever Given" blocked the canal for six days, causing significant disruption to international shipping timetables. More recently, shipping passing through the Red Sea has become a target for drone strikes by Houthi rebels, leading many logistics and shipping firms to reroute their cargoes around the Cape of Good Hope, resulting in longer shipping times and higher costs for customers.

10.4 Geopolitics and New Zealand's vulnerability

New Zealand's vulnerability to supply chain disruptions has increased due to heightened geopolitical tensions. The country relies heavily on international shipping for its trade, with a significant portion of its imports and exports being transported by sea. However, New Zealand no longer has a merchant shipping fleet that could be called upon during times of conflict or natural disasters to ensure the continuous supply of essential goods and raw materials. This lack of a merchant navy reserve leaves New Zealand exposed to supply chain disruptions caused by geopolitical events, such as the escalating tensions between China and Taiwan or the ongoing conflict between Russia and Ukraine.

If a major conflict were to break out between China and the United States over Taiwan, shipping throughout the Asia Pacific region would be significantly impacted. Affecting global shipping routes and trade including New Zealand's ability to import critical supplies and, importantly, to export its goods to pay for them.

Moreover, New Zealand's heavy reliance on China as a trading partner further exacerbates its vulnerability. In the event of a conflict involving China, New Zealand is likely to side with its traditional allies, the United States and Australia, in opposition to China. It should be noted, however, that siding with our old allies is not a foregone conclusion with New Zealand's involvement in NATO and the AUKUS (Tier 2) alliances being questioned by some on both sides of the political isle (Clarke & Brash 2024).

With thirty percent of dairy exports and a significant portion of total exports currently being exported to China, New Zealand is likely to be very exposed, however it chooses to align itself.

10.5 ERM and dairy farming operations

Further research needs to go into the area of ERM as it pertains to the dairy industry, and agriculture in general. That the sector could benefit from the development of a framework that is tailored to its specific needs.

Research suggests that companies that implement ERM in their business planning tend to be more resilient and often the process uncovers business opportunities during the process. However, given the relative homogeneity of Canterbury's dairy farms, the question should be asked as to whether it is necessary for each farm to have its own ERM plan? Could the planning and identification function be done by a collective of farmers (similar to the Regional Water Forums found around the country). Or could it be done by farmers in conjunction with their milk processing company or cooperative.

Another question that arises is what areas of risk really need to be identified and understood by farmers - are they best just to concentrate on the operational areas of the business that they can control and let others worry about the things they can't control? Or should they have at least some understanding of the big picture risks they potentially face?

Research suggests that going through the process of identifying risks and going through the ERM process does appear to lead to more resilient businesses and can uncover new business opportunities. These factors alone would suggest that, if the process can be undertaken with reasonable direction and cost, it would prove to be worthwhile for most businesses.

It is also possible that future governance trends or legal requirements may push businesses down a more focussed ERM pathway.

One of the interviewees from the insurance industry mentioned the use of technology to push information to customers. It is likely that new technologies, such as artificial intelligence, will lend themselves to helping farmers navigate through an ERM framework once developed. However, an understanding of each business, particularly regional or geographical nuances, will be critical and require the involvement of an engaged business owner.

11 Conclusions

11.1.1 Risk on the farm

Dairy farms in Canterbury are heavily reliant on diesel generators for electricity back-up when the grid goes down. In a situation where diesel supply becomes problematic, due to impassable roads or bridges, most farms will have at best, a month's supply of diesel to maintain electricity at the dairy shed. In the case of a Tsunami or weather-related disaster, it is likely that services would be restored relatively quickly and either the electricity network would be up and running, or diesel supply resumed, potentially through alternative ports or means of transport.

In the case of a large earthquake however, the length of time required to reinstate transport networks etc is unpredictable and would be dictated by its location and severity. At an individual farmer level, a number of factors would also need to be contemplated before the decision to continue operating as usual or dry cows off was taken. These might include the likely resumption of electricity supply (assuming it is lost), the ability of tankers to get to the farm to collect milk, the time of year and available feed levels for the animals and whether the milk processors had sustained damage or were still capable of operating.

Transferring risk by purchasing insurance is one of the strategies used in risk management. One of the observations that came out of the interviews was the suggestion that reinsurance is likely to becoming harder to obtain for certain premium categories, it is possible that damage caused by earthquakes could be one of those categories. Earthquake damage could pose as an existential threat to a dairy farm if it sustains significant damage and is unable to claim insurance in order to return the business to full working order. At the very least, farmers should be expecting the cost of insurance to continue to increase. However, an inability to obtain insurance may, for some, be too higher risk to sustain.

11.1.2 Closure of Marsden Point

The closure of Marsden Point oil refinery has reduced New Zealand's options for the supply of oil-based fuels. Prior to the refinery's closure importing crude oil meant NZ inc. could import from anywhere on the globe. From a national security perspective, this gave NZ the flexibility to refine what was required and, on the odd occasion, re-refine tainted batches of finished product rather than sending it back offshore to be treated. New Zealand is now totally reliant on the delivery by sea of refined fuels from overseas refineries, mainly in Asia. While New Zealand can import refined fuels from other parts of the globe, it is likely costs will increase significantly in the event of a significant conflict in the Asia Pacific region.

11.1.3 Merchant Navy

Without its own Merchant Navy, New Zealand is currently reliant on international commercial shipping operators for both the inward and outward passage of nearly all goods and services. In the event of a conflict in the Asia Pacific region, New Zealand is vulnerable to sanction or embargo by many of these operators. Finding ships willing to make the long, and potentially treacherous, journey across the Pacific during a period of conflict is likely to prove problematic and costly. At a national level New Zealand could (should) be discussing this apparently significant strategic weakness with our allies, particularly Australia who are in a similar position, and develop a mutual plan to ensure we have secured shipping capacity in case the worst should eventuate.

11.1.4 An ERM framework

Given the range of risks that Canterbury's dairy farming business are exposed to, some of which have been covered in this report, the development of an easy-to-use risk management framework might be helpful in assisting dairy farmers to consider threats to their business, be better prepared for future adverse events and make the business more resilient overall. It may also help farmers identify more productive or efficient ways of conducting their business or identify new business opportunities, either on or off farm.

However, further research needs to be conducted in order to ascertain how a suitable framework might be developed, how in depth it needs to be, and who might develop the framework. Given that many smaller farming operations are time and relatively resource poor, the framework would need to be simple to use and cost effective.

The framework proposed by Naude and Chiweshe (2017) might be a good starting point, with the involvement of as many key stakeholders as possible, including milk processors and co-op's, banks, accounting firms, insurance companies and central and local government and key rural supply companies.

11.1.5 New Technologies

Given the rapidly evolving nature of artificial intelligence, there may be the opportunity to develop a relatively sophisticated, yet simple to use ERM framework for farmers that they are likely to use and update regularly.

Similarly, the development of alternative types of electricity generation, such as grid-tied solar and battery, present farmers with new substitutes to generators. While until recently they have generally been considered too expensive to present as a viable alternative, prices have reduced considerably for both solar panels and batteries recently as international manufacturing capacity increases.

12 Recommendations

8) **On farm** – for farmers regular refilling of the diesel tank is important. Most farmers are on a regular fuel distribution route managed by their fuel supply company. Remote monitoring might also be an option for farmers who use a lot of diesel and need more regular topping up.
9) **On farm**- where the well for stock water is close to the dairy shed, the pump could be run from the same electricity mains switchboard as the dairy shed to minimise the need to have a second generator to run a stock-water pump.
10) **Generation technology** – farmers looking at their back-up electricity supply options could look at new generation technologies, such as PV solar and batteries, which are becoming more affordable and provide the farm with a layer of generation capacity that doesn't rely on off-farm inputs such as diesel.
11) **AF8 and SAFER –** given the high probability of a significant rupture of the Alpine Fault, it would be prudent for the New Zealand Government and local councils to continue its research and preparedness training alongside local councils and other relevant statutory bodies. Possibly, Tsunami should also be taken into account during these planning and training exercises.
12) **ERM research –** there is need for further research into the topic of risk management on farm, and the need for the development of an ERM framework for dairy farms and potentially the wider farming community.
13) **Diesel supply chain** – the government and fuel companies might consider diversifying the source of NZ's fuel supplies to include refineries in parts of the world, outside Asia.
14) **Merchant navy** – it is likely that the New Zealand Government is aware of, and already working towards finding a solution to New Zealand's lack of a Merchant Navy. If not, it should consider how it might work with allied nations, such as Australia, to mitigate the significant strategic weakness that both countries appear to have.

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14 Appendices

14.1 Appendix 1 – farmer profiles

	Age range	Region	Profile
1	50-60	North Canterbury	1 farm owned, manages another. Long-standing town supply dairy farming family (over 100 years).
2	50-60	North Canterbury	1 farm owned.
3	40-50	North Canterbury	1 farm owned. Long-standing town supply dairy farming family (over 100 years). Sold original family farm and developed a new dairy unit about 10 years ago.
4	50-60	Mid Canterbury	2 farms owned
5	40-50	Mid Canterbury	1 farm owned. Converted from cropping approx. 15 years ago
6	40-50	Mid Canterbury	1 dairy unit, run alongside a large sheep and beef unit. Also involved in farmer politics.
7	50-60	Mid Canterbury	GM- Farm Operations for large corporate farming entity. 30+ farms under management.

14.2 Appendix 2 – Industry participants

	Profession/Industry	Position
1	Accounting	Partner and lead- Risk Advisory Services
2	Banking	Senior risk officer- Global Projects and Credit Risk
3	Insurance	Manager – Enterprise Risk
4	Insurance	Head of Client Strategy
5	Insurance	Risk Specialist
6	Fuel supply	Innovation Lead