Expertise
and insight
for the future

Robert Roxborough

The worsening condition of fresh water in New Zealand and its relationship to the Fonterra Dairy Cooperative

Metropolia University of Applied Sciences
Bachelor of Business Administration
International Business and Logistics
Bachelor's Thesis
Date 30th April 2020

Metropolia
University of Applied Sciences

Author Title Number of Pages Date	Robert Roxborough The worsening condition of fresh water in New Zealand and its relationship to the Fonterra Dairy Cooperative. 38 pages 30th April 2020
Degree	Bachelor of Business Administration
Degree Programme	International Business and Logistics
Instructor/Tutor	Michael Keaney, Senior Lecturer

This thesis examines the relationship between the Fonterra Dairy Cooperative, its production methods, production inputs and the resulting pollution to New Zealand's lakes, rivers and streams. Fonterra has been chosen as the focus of this thesis, as it accounts for approximately 90 per cent of New Zealand's dairy industry, and it is the biggest exporter of milk products in the world. The eutrophication of freshwater, outbreaks of Escherichia coli, and water shortages are all shown to be significantly influenced by nutrient runoff from dairy farms and the excessive quantities of water being used to irrigate dairy farms in dry regions.

The worsening condition of New Zealand's fresh water has by in large occurred during the period since Fonterra was created. Therefore, this thesis aims to establish whether the intensity of dairy farming practices that cause water pollution and overconsumption have changed during Fonterra's period of control over the dairy industry. This was achieved by examining statistics relating to the causes of nutrient runoff, irrigation infrastructure expansion and nitrogen runoff from dairy farms.

This study found that since Fonterra was created, the growth rate in both dairy cattle herd numbers and the land being converted to dairy farms has reduced. Furthermore, the ratio of stock per hectare, and the growth in fertiliser use had also lessened. However, the area of land being irrigated had grown by 94 per cent, of which dairy farms accounted for 59 per cent in 2017. Statistics looking at nitrogen leaching from dairy farms did not reveal any conclusive trend changes since Fonterra's creation.

Keywords	Intensification, Fonterra, dairy industry, runoff, fresh water, pollution.

Contents

List of Figures and Tables

List of Abbreviations

NZ	New Zealand
GHG	Greenhouse gas emissions
PKE	Palm kernel expeller

E. coli	Escherichia coli
EEC	European Economic Community
NZDB	New Zealand Dairy Board
NZDG	New Zealand Dairy Group
KCD	Kiwi Cooperative Dairies
GDP	Gross domestic profit
MAV	Maximum acceptable value
FTA	Free trade agreement
RMA	Resource management act
N	Nitrogen
P	Phosphorus

Glossary

Stratified lake	The separation of a lake into three temperature layers
Epilimnion	The top layer of a stratified lake
Hypolimnion	The bottom layer of a stratified lake
Anoxic	An environment without oxygen
Phytoplankton	Water based microscopic organisms

Micro-algae	Microscopic algae found in both water and its sediment
Macrophyte	An aquatic plant large enough to be seen by the naked eye

1. Introduction

"When the well is dry, we know the worth of water"
-Benjamin Franklin

In 2005, the environmental philosopher Glenn Albrecht coined the phrase 'Solastalgia', which he described as "the homesickness you have when you are still at home", more specifically, it is the distress caused by environmental change and a longing for the environment to be the way it used to be (Albrecht, 2005). The concept of 'Solastalgia' is pertinent with regards to this thesis, as in all likelihood it is the affliction of 'Solastalgia' on the researcher, that has steered the direction of this thesis towards a mission to discover who is behind the 'muddying' of New Zealand's (NZ) once pristine rivers and lakes. A quick Google search of 'New Zealand's polluted rivers' will generate a multitude of domestic and international media reports highlighting the loss of what every New Zealander regards as their 'birth right'- to swim, fish and gather food from rivers lakes and streams.

A recent Colman Brunton poll conducted on behalf of NZ fish and game (a collective made up of NZ's regional fish and game councils) showed that 82 per cent of respondents said they were "extremely" or "very concerned" about the pollution of rivers and lakes, more than any other issue on the survey, which included child poverty, climate change and the cost of living (NZ fish and game, 2019). The concerns expressed by New Zealanders in the survey would surely evoke many to ask the question: who is responsible? The answer, of course, is everyone. However, in the NZ psyche, it is dairy farming and its poster child Fonterra who have been cast as the perpetrator. The reason it could be suggested is its image of excess, generated by Fonterra's status as one of the world's biggest dairy producers, accounting for 19.3 per cent of global production and contributing 7.8 per cent towards NZ's GDP (2017), a hard pill to swallow when the NZ media rightly paint dairy farming and Fonterra as a major polluter (Ballingall & Pambudi, 2017) (MacManus & Nadkarni, 2019). Furthermore, a study by Foote et al estimated the cost of restoring the environmental damage done by the NZ dairy industry to between NZ$2 billion to NZ$15 billion dollars annually, more than the NZ dairy industry's annual exports (Foote, 2014).

Though much of this thesis focuses on answering questions of Fonterra's culpability, the serious consequences of what polluted freshwater means for current and future generations should also be considered as a reason for drawing attention to this issue. Water scarcity is already becoming an issue in NZ. Over the past 15 years, records for days without rainfall have been repeatedly broken, with modelling by the National Institute of Water and Atmospheric Research predicting a 5 to 10 per cent increase in time spent in drought by 2050 (Johnston, 2013) (Ainge Roy, 2020). As well as reducing the quantity of drinking water available, water scarcity also reduces the quality of water available, with the rates of gastrointestinal disease increasing in ground and surface water sources as a consequence of drought (Britton, et al., 2010). The combination of less water being available in the future alongside increases in future demand makes the dairy industry's high consumption of clean water coupled with its corresponding discharge of nitrogen, phosphorus and E. coli, an important discussion to have now.

The purpose of this thesis will be to explain how dairy farming in NZ has over-exploited natural resources to achieve massive profits. The Fonterra dairy cooperative has been chosen as the focus of this research, as it has processed between 88 and 96 per cent of NZ's entire milk production since 2001, therefore, in the opinion of the researcher, it holds a proportionally large share of accountability for the misdeeds of the entire industry. Furthermore, there is a need to better understand what factors combined to create a culture of profit over ethics and to provide the reader with a broad spectrum of knowledge that will examine the role of Fonterra as either the root of the problem, or merely a symptom of bigger issues.

1.1 Motivation

This thesis is motivated by the need to establish an understanding of how and why the once pristine waters of NZ have been damaged over the last two decades by those exploiting the environment for profit. The researcher became interested in the connection between the dairy industry and freshwater pollution from media coverage of the 'dirty dairying' campaign run by New Zealand Fish and Game. The 'dirty dairying' campaign identified dairy farms as a major contributor in the pollution of waterways, leading to a public backlash against the dairy industry, which up until that point had largely evaded any scrutiny of its ethics and production methods.

1.2 Further problematic aspects of Fonterra and the NZ dairy industry

Although beyond the scope of this thesis, there are several other environmental and ethical issues worth bringing to the attention of the reader to provide a more complete view of Fonterra and the NZ dairy industry's problematic business model.

In the current culture of climate change awareness, it is important to point out dairy farming in NZ as a significant contributor to greenhouse gas emissions. NZ's greenhouse gas emissions (GHG) per capita are among the top five worst of all OECD countries, with 49 per cent of NZ's GHG emissions coming from agriculture, and about one quarter from dairy farming alone (Ministry for the Environment, 2010) (Pinares-Patiño, et al., 2009).

Furthermore, the intensification of dairy farming in NZ has created a need for animal feed to be imported into NZ for the purpose of grazing cattle away from the milking area, supplementing feed during drought, increasing the ratio of supported stock per hectare, and extending the period a cow can lactate. Controversially, the imported feed supplement of choice by NZ dairy farmers is palm kernel expeller (PKE), a by-product of palm oil extraction. Palm oil production is responsible for the destruction of native forest in Malaysia and Indonesia, putting already endangered animals like the orangutan under increasing pressure (World wide fund for nature, n.d.). PKE imports into NZ have increased significantly since 2003, going from 0.93 million tonnes to 2.5 million tonnes in 2019 (Index Mundi, n.d.).

Finally, NZ's entire agricultural sector is in an ethical bind, as it sources over 70 per cent of its phosphate rock (used in fertiliser) from the Western Sahara, which is illegally occupied by Morocco. Unlike other major farming countries that typically have more diverse land uses, NZ dedicates between 80 and 90 per cent to raising animals, creating a heavy reliance on phosphorus fertilisers. Moreover, phosphorus rock is often contaminated with heavy metals like cadmium, fluorine and uranium. These heavy metals accumulate in the soil where cadmium, in particular, can be taken up in food and has a similar toxicity to lead or mercury. (Mitchell, 2018)

1.3 History of the NZ dairy industry

New Zealand's remote geographical location relative to its export markets meant that perishable goods like meat and dairy products could not be exported to the lucrative markets of Europe and North America. Only the development of mechanical refrigeration for export vessels enabled NZ to be one of the first countries in the world to prove the viability of exporting perishable agricultural goods over long distances by sea. In 1882, NZ's first long-distance export of meat and butter was sent from Port Chalmers in the South Island to London onboard the sailing ship *Dunedin*. This led to the development of an extensive frozen meat trade from NZ and Australia, to the United Kingdom and kickstarted an agricultural boom in both NZ and Australia respectively. (Evans, 2004)

New Zealand's heavy involvement in the First World War created a need for the NZ state to take control of its main export commodities, resulting in a period of artificially stabilised prices under the state's control. In 1921, following the end of the First World War, state controls on exports were ceased, resulting in a depression of market prices (Gilmour, 1992). The reaction from agricultural producers was to demand the re-introduction of state control measures, and on 28 August 1923, the New Zealand Dairy Board (NZDB) was created to take total control of NZ's dairy exports (Parliament, NZ, 1923).

The NZDB, as with similar marketing boards internationally, was a legislative means of controlling the dairy market to suit the interests of specific groups. Marketing boards are also commonly associated with the control of market entry, prices, quantities produced, quantities sold as well as the fair distribution of costs and benefits to both the producer and consumer alike. The NZDB was no exception and provided market stability, control over prices, greater efficiencies through economies of scale and a reduction of market conflict. (Gilmour, 1992)´

Over the ensuing years, NZ's agriculture industry enjoyed great success, by and large due to its protected access to the British export market, and by the government subsidies protecting farmers from market fluctuation. The state protectionism afforded to the NZ dairy industry allowed farmers to enjoy a period of relatively high income with relatively low exposure to risk, as the state isolated the producers from the market. However, with the UK's accession to the European Economic Community (EEC) in 1973, NZ's main export market was significantly reduced by blanket quotas and tariffs imposed on goods coming from outside of the EEC. Naturally, the reduction in NZ agricultural exports to the UK greatly impacted the NZ agricultural industry and forced the industry into a period of restructuring. To add further intensity to this already tumultuous period, NZ's 1984 general election brought the Labour party to power, and with the new government came the neo-liberal economic policies of its finance minister, Roger Douglas. Roger Douglas's radical reforms brought about the end of farm subsidies and deregulated the agricultural industry. Without subsidisation, the business model for dairy farmers had now become one of relatively low income with high market risk, and as a result, many farmers either sold up, went bankrupt or diversified. (Evans, 2004)

In the decade following Roger Douglas's reforms, a focus returned to the re-structuring of the dairy industry itself, although these sentiments were nothing new. Since the 1970s there had been calls from within the industry for growth through improved economies of scale, as well as better coordination of its production and marketing. One of the biggest problems farmers faced with the industry structure at the time was the bundled price they received for milk which did not distinguish between the cost of producing raw milk and the return on milk processing capital, often leading to overproduction. Moreover, competition in NZ's domestic market was being severely throttled by the use of a single export and marketing desk to represent all of NZ's dairy cooperatives and the fact that the number of dairy cooperatives in NZ had been drastically reduced due to mergers. The relatively small size of the domestic dairy market in NZ meant that any new entrant into the market could only expand through exports, and because all dairy exports needed approval from its cooperative competitors (who owned the NZDB), any new entrants were unlikely. (Evans, 2004)

1996	1997	1998	1999	2000	2001
Kiwi Dairies	Kiwi Dairies	Kiwi Dairies	Kiwi Dairies	Kiwi Dairies →	
Tui Milk →					
Northland Co-op	Northland Co-op	Northland Co-op	*Northland Co-op* →		
Kaikoura Dairy	Kaikoura Dairy	Kaikoura Dairy	*Kaikoura Dairy* →		
Tasman Milk	Tasman Milk	Tasman Milk	*Tasman Milk* →		
Marlborough Milk Ltd	Marlborough Milk Ltd	Marlborough Milk Ltd	*Marlborough Milk Ltd*		
					Fonterra Cooperative Group
Southland Co-op	*Southland Co-op* →	*South Island Co-op* →	New Zealand Dairy Group	*New Zealand Dairy Group* →	
Alpine Dairy	*Alpine Dairy* →				
Bay Milk Products	*Bay Milk Products* →	New Zealand Dairy Group			
East Tamaki	*East Tamaki* →				
New Zealand Dairy Group	New Zealand Dairy Group				
Tatua	Tatua	Tatua	Tatua	Tatua	Tatua
Westland	Westland	Westland	Westland	Westland	Westland

Figure 1. Consolidation of the New Zealand milk market (Trechter, et al., 2003)

By 2000, the total amount of dairy cooperatives in NZ had gone from 13 in 1996, to just 4 by 2000 (Figure 1), with the NZ Dairy Group (NZDG) and Kiwi Cooperative Dairies (KCD) holding the dominant market share between them (Trechter, et al., 2003). As part of the proposed restructuring of the dairy industry, the idea of a mega-merger was floated between the NZDB, the NZDG and KCD (Trechter, et al., 2003). Those campaigning for the mega-merger promoted it as a way to save an estimated NZ$120 million annually while improving the ability of NZ's dairy industry to compete in international markets (Trechter, et al., 2003). Cost savings were expected to be achieved through the streamlining of the supply chain, the removal of duplicate facilities and job positions with further savings coming through economies of scale (Trechter, et al., 2003). By early 2001, the NZ government had set out a regulatory package to support a possible merger between the NZDG, KCD and the NZDB (NZ Government, 2001). Then in July 2001, 84 per cent of farmers holding membership of the NZDG and KCD voted to accept the merger, paving the way for the Fonterra Dairy Cooperative's creation by October of the same year (Norgate, 2013).

At the time of the merger, Fonterra was made up of about 12,300 farmer shareholders, making up 96 per cent of the NZ dairy industry (New Zealand Parliament, 2001) (Trechter, et al., 2003). Once formed, Fonterra was responsible for around 30 per cent of all global dairy exports, accounting for 7 per cent of NZ's GDP (Norgate, 2013), (Trechter, et al., 2003). Currently, Fonterra is in a period of restructuring, due to severe losses in its Chinese operations and a NZ$183 million pay-out to the French food company Danone, resulting from legal action taken by Danone over a botulism scare in 2013 (Bridgeman, 2019) (Gray, 2017). These expenses led to Fonterra posting losses for the first time in 2018 and 2019, despite generating revenues of approximately NZ$20 million in both years respectively (Fonterra Dairy Cooperative, 2018) (Fonterra Dairy Cooperative, 2019). Fonterra's share of the NZ market has also been weakened, currently accounting for 88 per cent, down from 96 per cent, with the number of farmer shareholders down to 10,000, from 12,300 (Fonterra Dairy Cooperative, 2020). Despite its current problems and the increased competition for developing markets, Fonterra remains the world's largest dairy exporter and the fourth largest dairy company globally (Workman, 2020) (van Battum & Ledman, 2019).

1.4 Thesis content

"Chapter 2. Dairy farming and its relationship to freshwater" aims to demonstrate the connection between the pressure dairy farming puts on water resources and the resulting degradation of freshwater. Making this connection begins with the identification and development of theories that reveal how the trophic state of freshwater can be altered. Furthermore, these changes in trophic states are then connected to dairy farming operations through existing research on nutrient runoff. The presence of E. coli in drinking water and water shortages are also discussed in relation to the dairy industry. Additionally, macro-environmental factors that pushed dairy industry growth past the environmentally sustainable threshold will be identified. Finally, to have a balanced discussion, the effects of the dairy industry on NZ's fresh water will be reviewed from three different perspectives, which will be followed by a summary of the facts, leading to the introduction of the main thesis question.

"Chapter 3. Analysis" will examine publicly available statistical information, sourced predominantly from Statistics NZ Tatauranga Aotearoa, which is the official data collection agency of the NZ government (Statistics NZ, n.d.). The outcome of the analysis will be discussed, which will be used to form a conclusion.

2. Literature review and analysis

2.1 Eutrophication - conception and evolution

The concept of eutrophication has its origins in the research Carl Albert Weber, the German biologist who in 1907 was the first person to use the term *eutrophe, mesotrophe,* and *oligotrophe* to describe the transformative state of flora in peat bogs over time (Weber, 1907) (Ansari, et al., 2011). The process Weber described was essentially the reverse process of freshwater eutrophication, whereby in Weber's description, the initial state of bog vegetation (which Weber called eutraphent) required high levels of nutrients in the surrounding soil. The natural elevation of the bog water over its surroundings, caused nutrients in the soil to leach away, resulting in the bog's transformation into a state of oligotrophe, essentially becoming hospitable to only the flora which could tolerate very low nutrient concentrations. (Ansari, et al., 2011)

Following on from Weber's work, Einar Naumann conducted research, looking into the nutrient content of lakes in Sweden using Weber's terminology of oligotrophic, mestrophic and eutrophic (Naumann, 1919). Naumann's definition of eutrophic differed from Weber's, as he interpreted it to mean 'good nourishment' when referring to the algal content of lakes. The algal content Naumann referred to could not reliably be measured at the time of his research (1919), therefore Naumann redefined each of Weber's categories according to the physical appearance of the water during the summer months, and by the phytoplankton algal groups present in the water (Ansari, et al., 2011). In parallel to Nauman's research, the German limnologist August Thiennemann was able to show through data taken from lakes in Northern Germany that some stratified lakes experience oxygen depletion in their hypolimnion (Thiennemann, 1918) (Ansari, et al., 2011). The research by Thiennemann and Naumann still holds much relevance today, as their work combined was used to create the oligotrophic-eutrophic paradigm which is still used today in the identification of lake topography (Tockner & Likens, 2009).

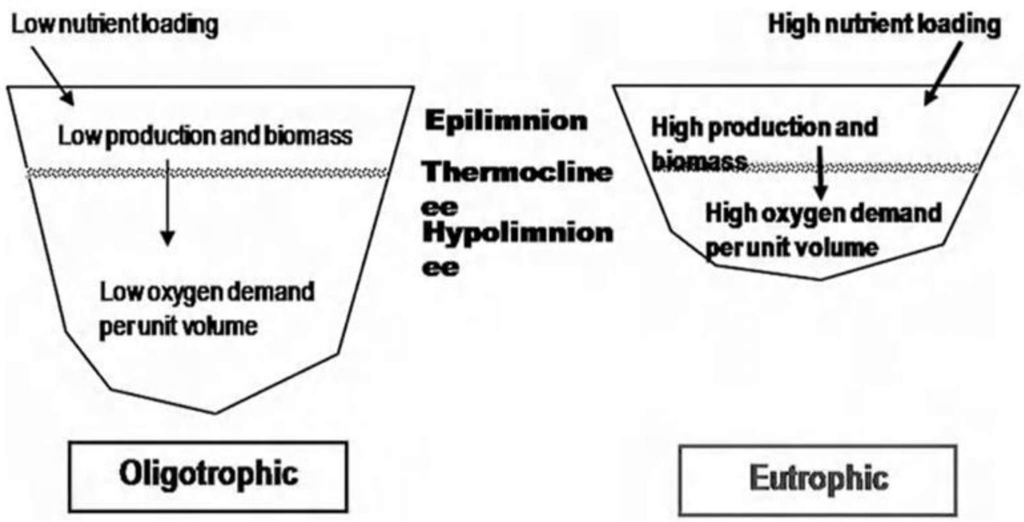

Figure 2. The oligotrophic-eutrophic paradigm. (Ansari, et al., 2011)

The oligotrophic-eutrophic paradigm (see figure 2 above) shows what at the time of Naumann and Thiennemann was regarded as the typical lake forms of each trophic state; the oligotrophic lake being deep, receiving nutrient-poor run-off, and only producing small quantities of organic matter in the well-lit upper layer (epilimnion). Therefore, as only small quantities of organic matter were being produced, a proportionally small amount of this material sank to the lower layer of the lake (hypolimnion), consuming only a little oxygen there during the warmer summer months. In contrast, the eutrophic lake is typically but not necessarily shallower, the run-off entering the lake is nutrient-rich, with rivers and groundwater feeding into it. Production of organic matter is greater than in an oligotrophic state, therefore more organic matter settles in the hypolimnion layer, which is more susceptible to the depletion of dissolved oxygen (anoxic), as a result becoming anoxic during the warmer summer months. (Ansari, et al., 2011)

As a result of the oligotrophic-eutrophic paradigm, freshwater eutrophication was to be simply defined by Naumann as "An increase of the nutritional standards (of water) especially concerning nitrogen and phosphorus" (1931 cited in (Stewart, 1967). While Naumann's definition captures the core meaning of eutrophication, Dokulil and Teubner's contemporary definition built on Naumann's work by including the consequences and causes of the process. They defined the eutrophication in freshwater systems as:

> A syndrome of ecosystem responses following the increase in concentration of chemical elements (nutrients) to an extent that the primary productivity of the ecosystem is enhanced. Nutrient

> enrichment can be natural or artificial, usually caused by human activities. Depending on the degree of nutrient enrichment, many subsequent negative environmental effects may occur. (Ansari, et al., 2011)

Dokulil and Teubner's definition highlighted two key points; that nutrient enrichment can be natural, although it is usually caused by human activity; the results of eutrophication have negative environmental effects. Specifically, the negative effects of nutrient enrichment being the stimulated growth of the water-based phytoplankton/attached plants/micro-algae or macrophyte biomass, depending on water flow (Ansari, et al., 2011). Amongst other things, the resulting biomass blocks light to the lower levels of water, asphyxiates aquatic life by removing dissolved oxygen from the water, is conducive to toxic algal blooms, and leads to ecosystem collapse in extreme cases (Ansari, et al., 2011). Furthermore, the reference to human activity being the most likely cause could either mean direct point sources like stormwater or sewage, or the more problematic and difficult to control diffuse runoff from agricultural or urban land. It is this last point that falls within the scope of this thesis and will help to direct its narrative.

2.2 Nutrients, dairy farming and eutrophication

As Naumann's 1931 eutrophication definition acknowledged, the presence of nitrogen and phosphorus are key enablers in the process of the freshwater eutrophication-subsequently, these are the two most popular forms of externally sourced nutrients applied to NZ's dairy pastures as a means of compensating for the nutrients lost from cropping and runoff (Statistics NZ, 2019b). Dairy farming's contribution to nutrients in freshwater is disproportionally high compared to other land uses. In the Waikato region, NZ's main dairy region, dairy farming is responsible for 68 per cent of nitrogen and 42 per cent of phosphorus in waterways from the exploitation of just 22 per cent of the land available (Environment Waikato, 2008). Nitrogen in the form of urea, diammonium phosphate (DAP), ammonium sulphate (SOA) and phosphorus in the form of superphosphate is applied as fertiliser (Statistics NZ, 2019b).

Additionally, dairy cattle themselves contribute significantly to nitrogen over-enrichment, as it has been shown that cattle grazing a pasture diet can excrete between 75%- 95% of the nitrogen (N) they consume through urination (Eckard, et al., 2010). The amount of N from a single urination event is equivalent to applying N at a rate of between 800-1300 kg N/ha (Eckard, et al., 2010), with studies having demonstrated the average leaching loss of N from urine patches to be 20% (Selbie, et al., 2015; Cameron, et al., 2013).

Figure 3. Cattle trampling soil into a stream. Source: (Fondation Hëllef fir d'Natur, 2020)

Phosphorus (P) is naturally occurring from the weathering of rock and soil; however, additional phosphorus is commonly brought into farms, usually as fertiliser and/or given to cattle as a dietary supplement, therefore indirectly being applied to pasture in the cattle's effluent. The physical characteristics of P mean that it can attach itself easily to soil particles, enabling it to enter waterways through the erosion of soil. On dairy farms with unfenced waterways, the soil is often trampled into the water when cattle cross or drink from freshwater bodies (as seen in Figure 3).

The application of phosphorus fertiliser on steep land can also lead to the erosion of soil into bodies of fresh water. (Dairy NZ, 2013) The levels of P applied to agricultural land are crucial to the trophic state of the surrounding water bodies, as more often than not, it is the supply of P in freshwater that is the limiting factor of algal growth (Ansari, et al., 2011). The proven connection between eutrophication and dairy farming practices means that Fonterra has been forced to acknowledge at least some of the impacts milk production has on the environment, even commissioning public relations campaigns to show the public how they are reversing the damage done (Fonterra Dairy Co-operation Ltd., 2018). However, currently in NZ, 57 per cent of lakes tested are in a eutrophic state or worse, therefore further research needs to be conducted to evaluate the effectiveness of Fonterra's remedial work (Statistics NZ, 2019d).

2.3 The increasing pressure on freshwater resources from agriculture

According to the United Nations (U.N.), the growth rate of the world's human population is unlikely to stabilise during the current century, with it being expected to increase by 2 billion people over the next thirty years, reaching a predicted 11.2 billion by the year 2100. (The United Nations: Department of Economic and Social Affairs, 2019) With every extra person born, it can be expected that a corresponding increase in demand be placed on water resources, with the availability of clean water for human consumption becoming increasingly difficult to maintain. It is predicted that changing weather patterns caused by human activity will in many countries cause destabilisation of food security through water shortage, conversely, some areas will receive excess rainfall, causing flooding and potable water shortages due to contamination (Schewe, et al., 2013). The increasing scarcity of clean water sources over the coming decades makes the way NZ utilises its water resources now (especially when it comes to agriculture) of vital importance if there is to be a guaranteed supply of clean water in the future.

In NZ, urban water catchments are generally in good supply and of excellent quality. However, in recent years, multiple cases of Escherichia coli (E. coli) have been recorded in town water supply catchments, resulting in periods when tap water could not be consumed without being boiled first (Gorman, 2019) (Paddy, et al., 2019). E. coli outbreaks have also been recorded in many of NZ's lakes and rivers, negatively affecting some of New Zealander's favourite summer pastimes, notably swimming, fishing and the traditional gathering of food (Ministry for the Environment, Stats NZ, 2017). Cattle are a major reservoir to (toxic to human) strains of E. coli, colonising the intestinal tract and entering water supplies through faecal contamination (Pruimboom-Brees, et al., 2000). This supports statistics showing concentrations of E. coli are significantly higher in areas of both human and animal inhabitation, with urban areas 22 times higher, and agricultural areas 9.5 times higher than when compared to uninhabited areas surrounded by native forest (Ministry for the Environment, Stats NZ, 2017). In the Waikato, the extent of the problem is evident, as bacteria levels in 70 per cent of sites sampled by the Waikato regional council in 2008, were too high to swim safely (Environment Waikato, 2008). While all mammals living close to freshwater can be sources of E.coli, cattle are considered the main incubator for the pathogen, as they can store E.coli in their intestinal tract without becoming sick themselves, and are capable of producing relatively large quantities of manure, which often enter into freshwater supplies (Pruimboom-Brees, et al., 2000). Moreover, one dairy cow can excrete faecal bacteria equivalent to approximately 14 people, meaning that NZ's dairy cow population of approximately 5 million excretes the equivalent bacteria of 70 million people (Environment Waikato, 2008) (Dairy NZ, 2019). However, unlike human waste that is usually treated and released into the environment in a controlled manner, the excretion of faecal bacteria by cattle is difficult to control due to the un-treated and diffuse manner in which it enters the environment. It is estimated that between 18,000 and 34,000 people in NZ are infected every year by drinking waterborne gastrointestinal disease (Ball, 2006).

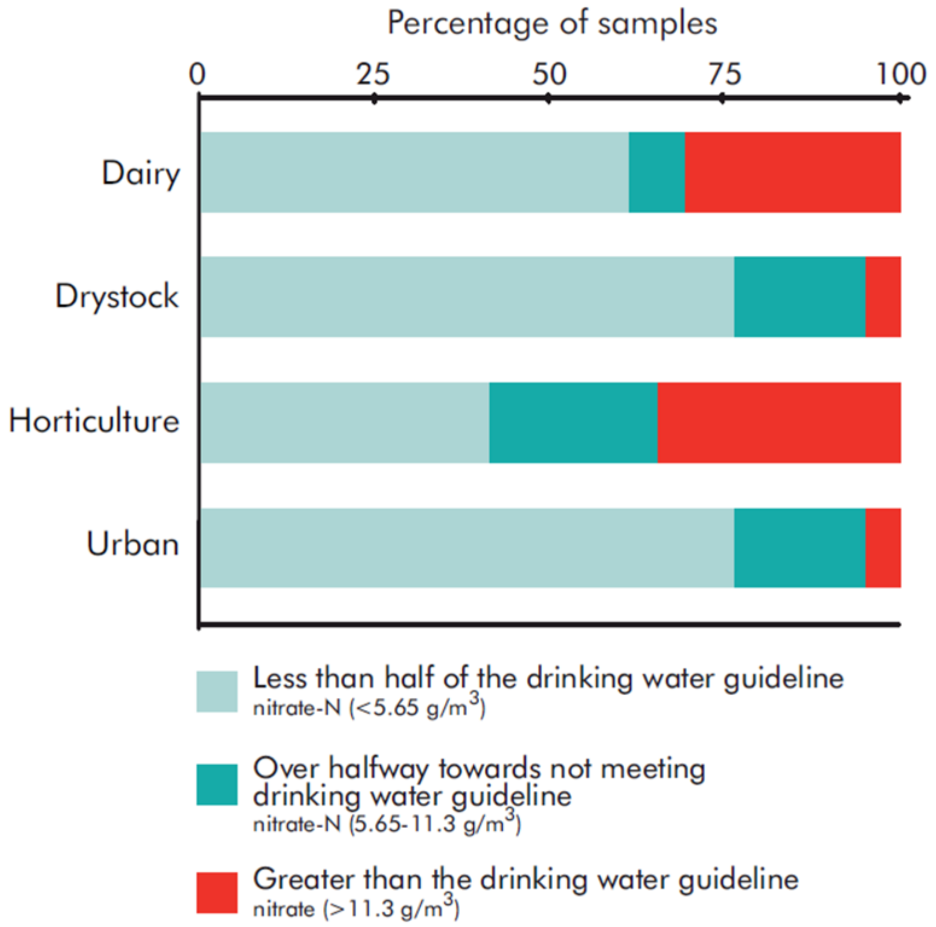

Figure 4. Percentage of Waikato groundwater sites under different land uses that have excessive, elevated or low nitrate levels. (Environment Waikato, 2008)

Further pressure on freshwater resources comes from high nitrogen levels in drinking water becoming dangerous for human consumption. As previously mentioned, N has been shown to leach from agricultural land into the surrounding waterways from where it can often migrate into town drinking water supplies. In NZ the Ministry of Health stipulates drinking water to have a maximum acceptable value (MAV) of 50mg/L or >11.3g/m³ of nitrates per volume of water (Ministry of Health, 2008). In the Waikato, its regional council monitors groundwater in 110 wells, of which 16 per cent exceeded the ministry of health's MAV. Of those sights tested under dairy farming land, approximately 30 per cent exceeded the MAV for nitrates, which contrasts to those sites tested under dry stock farmland, which failed just 5 per cent of the time (see Figure 4) (Environment Waikato, 2008). In 2018, the Canterbury regional council's annual survey of groundwater quality revealed that of the 306 wells it tested, 7 per cent exceeded the MAV for nitrates (Canterbury Regional Council, 2018). No data related to land use was available for Canterbury, therefore there can be no distinction between dairy farms and other land uses.

According to the World Health Organisation (WHO), high nitrate levels in drinking water are responsible for the blood disease methemoglobinemia (blue baby syndrome), which decreases the body's ability to carry oxygen around the body (World Health Organisation, n.d.). This mostly affects bottle-fed infants. However, some adults with underlying health issues can be affected too (World Health Organisation, n.d.). The WHO also states that intense farming practices are at the root of the problem, with most cases found in rural populations where groundwater is used for human consumption (World Health Organisation, n.d.). Although cases of methemoglobinemia are now rare in industrialised countries, the monitoring and management of groundwater in NZ should still be considered vital, as in NZ, 40 per cent of all drinking water is taken from groundwater supplies (World Health Organisation, n.d.) (Taylor, et al., 1997).

2.4 Irrigation – give and take

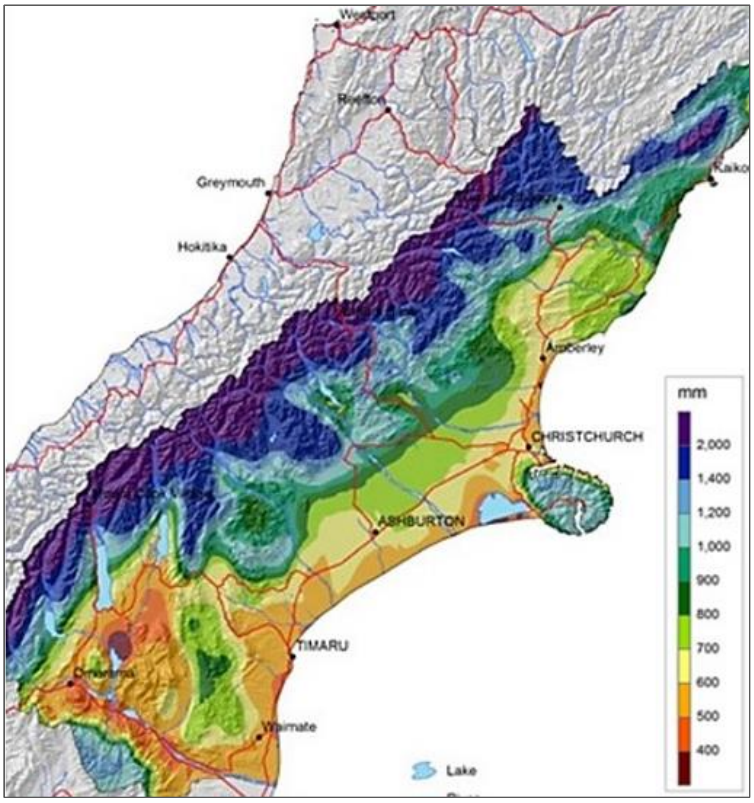

Figure 5. The median annual total rainfall in the Canterbury region of New Zealand. (Macara, 2016)

How dairy farming practices alter the natural trophic state of the surrounding water catchments, is only one of the environmental afflictions caused by dairy farming. The quantity of water used, and how water is used by the dairy industry has also been shown to have severely detrimental consequences on the surrounding environment (Brown & Harris, 2005). In NZ, partly due to its diverse landscape, weather patterns differ greatly within relatively small distances. As an example, the Canterbury Plains in the South Island, where a typical annual average rainfall is 500 mm, contrasts drastically with the nearby elevated regions which experience ten times that amount (see Figure 5)

These dry regions of NZ would naturally not receive sufficient enough rainfall to support dairy farming, therefore, traditionally these areas were dominantly used for sheep grazing and cropping, which do not require as much water to be productive (Pangborn & Woodford, 2011). To successfully run dairy farms in these dry regions, large scale irrigation projects have been implemented to a point, that by 2017, 747,000ha of land was being irrigated in NZ. (Statistics NZ, 2019a). Irrigation enabled dairy farming in the dry regions to become viable, to the extent that it is estimated that 97% of the 4.8 billion cubic metres of water used on NZ dairy farms is used only for irrigation (Kitto, 2018). The massive volume of water being used to irrigate NZ dairy farms is drawn from rivers, aquifers and stored surface water (Bloomer, et al., 2015). The effects of drawing such large volumes of water from water sources in already dry regions are profound, as has been observed at the Rangitata River in Canterbury, where water flow is halved during the irrigation season, from 98 cumecs (m^3/s) to about 50 cumecs (Taylor, et al., 1997).

In addition to its effect on river flows, irrigation can potentially affect groundwater quality through the leaching of nutrients and contaminants (Taylor, et al., 1997). Furthermore, because of the high capital investment of irrigation infrastructure, as well as high overhead costs, farmers are often motivated to recover higher returns from their land, requiring higher inputs of production such as fertiliser, further increasing nutrient runoff (Brown & Harris, 2005). However, for irrigation to significantly affect groundwater quality, certain environmental characteristics must be present, like those found in the Temuka area of South Canterbury where shallow aquifers are present under a thin soil layer, and rainfall is low enough for irrigation water flows to be dominant (Taylor, et al., 1997).

In the period since Fonterra was created, statistics show that irrigated land area in NZ has almost doubled (Statistics NZ, 2019a). Although irrigation has enabled and improved dairy farming in many of the drier regions of NZ, it also places increased pressure on river flows, as well as indirectly placing pressure on land and freshwater by enabling more intensive farming practices (Statistics NZ, 2019a). The rate of irrigation expansion during Fonterra's period of market dominance and its negative effects on freshwater warrants further research to determine whether Fonterra was a driving factor in its growth.

2.5 Macro-environmental influences on Fonterra's growth

The rapid growth of Fonterra's export market is regarded by the researcher as the major driver of Fonterra's push to increase milk production past an environmentally sustainable level. Political influence has been important, in firstly allowing Fonterra to be created, and secondly in providing the regulatory framework for it to thrive as a business. In 2001, the Labour-led government at the time pushed through the Dairy Industry Restructuring Act (DIRA) by making the merger of the NZDC and KCD exempt from the competition policy provisions of the Commerce Act 1986, therefore, avoiding the usually required authorisation of the Commerce Commission (Clarke & Sutton, 2001). The DIRA included several regulatory measures which were intended to promote market competition, despite Fonterra's domestic monopsony. These regulations included:

> Subpart 5- Regulation of dairy markets and obligations of new co-op
>
> b) New co-op must accept applications by new entrants and shareholding farmers to supply it with milk, as shareholding farmers.
>
> (d) Shareholding farmers who withdraw from new co-op, and cease or reduce supply, must receive their capital in new co-op without unreasonable delay.
>
> Subpart 5A—Base milk price
>
> (1) The purpose of this subpart is to promote the setting of a base milk price that provides an incentive to new co-op to operate efficiently while providing for contestability in the market for the purchase of milk from farmers.
>
> Section 73- New co-op must accept application
>
> (2) New co-op must accept an application to increase the volume of milk supplied as a shareholding farmer to new co-op that is made by a shareholding farmer in an application period.
>
> Source: (New Zealand Parliament, 2001)

The DIRA intended to remove the barriers of entry and exit to the Fonterra cooperative; guarantee a competitive base price for milk supplied to Fonterra; make it compulsory for Fonterra to accept all milk supplied to it by its cooperative members. The passing of the DIRA by parliament cleared the way for NZ's two biggest dairy cooperatives plus the NZ Dairy Board to merge into what would eventually become the Fonterra dairy cooperative. In statements made by the then prime minister Helen Clark and her minister for agriculture Jim Sutton, they expressed legitimate concerns about the creation of a monopsony, which would likely use its market dominance to reduce competition and efficiency, even with the implementation of the DIRA (Clarke & Sutton, 2001). Nevertheless, the government rationalised the merger because of its potential to maximise returns from the dairy industry in the short-term, through deregulation of the dairy sector and by creating economies of scale (Sutton, 2001). The government estimated that the proposed mega cooperative would account for 96 per cent of the NZ dairy industry, 20 per cent of total exports and contribute 7 per cent of the GDP (Sutton, 2001).

It was not just the potential for wealth that motivated the government to approve the merger, as there had been pressure mounting from within the dairy industry for some time to remove the NZDB's single export desk, as it was seen as having too much control over overseas marketing and hampering the efforts of the smaller cooperatives to expand into new markets (Sutton, 2001). The removal of the NZDB turned out to be a pivotal moment in the evolutionary course of the NZ dairy industry, through regulation changes that allowed competition in national and international markets by the commodity owners, and not by regulatory intervention by NZ authorities (Evans, 2004).

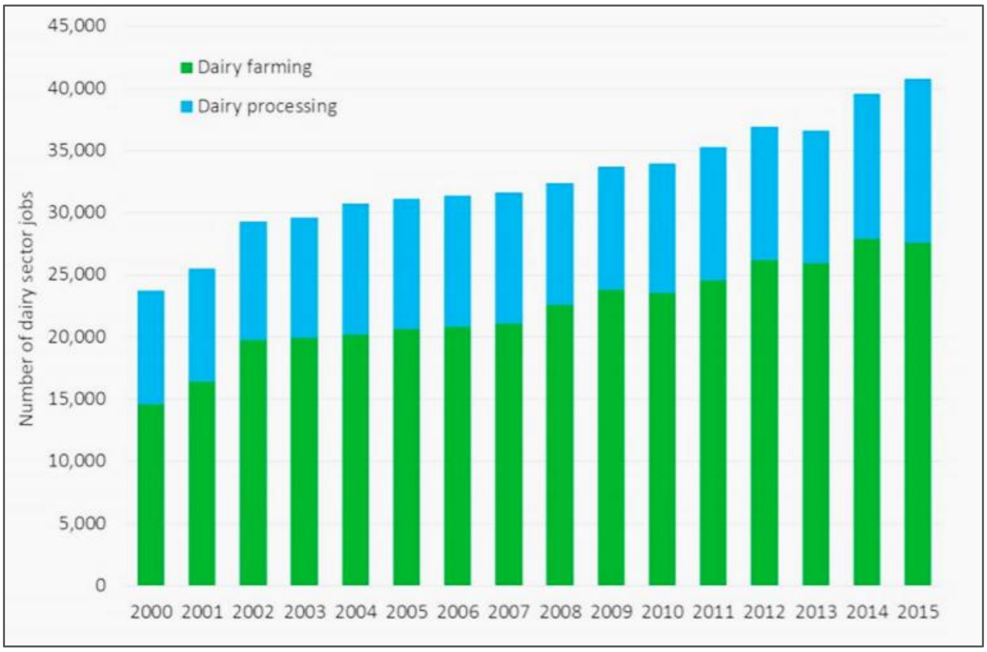

Figure 6. The number of people employed by the NZ dairy sector. (Ballingall & Pambudi, 2017)

From the government's actions and statements in 2001, there was an obvious enthusiasm for this new mega cooperative and its great potential to expand and thrive in new and existing overseas markets. As seen in Figure 6, the decision to allow the merger enabled the dairy industry and Fonterra to grow significantly, with the dairy sector's employment growth rate between the years 2000 and 2015 averaging 3.7 per cent a year, more than double the rate of NZ's total employment (Ballingall & Pambudi, 2017).

A further example of governmental influence on Fonterra's growth came in 2008, with the signing of the free trade agreement (FTA) between NZ and China. The agreement meant that NZ was the first country in the OECD to gain near tariff-free access to China, gifting Fonterra early market penetration (Ministry of Foreign Affairs and Trade, 2008).

As part of the FTA, tariffs on NZ's exports to China were to be reduced in stages, eventually removing tariffs on 96 per cent of NZ's exports, equating to annual duty savings of NZ$115.5 million (calculated on 2008 trade levels) (Ministry of Foreign Affairs and Trade, 2008). For Fonterra and the NZ dairy industry, this led to significant growth in its exports to China, increasing from NZ$0.4 billion in 2007 NZ$5.3 billion in 2019 (Statistics NZ, 2020b). However, the FTA with China, despite its financial benefits, also created concerns around NZ's environmental capacity to supply such a large market. An un-named public official was quoted in a 2015 interview as saying "There have been big shifts in land use to provide dairy products to China…We are an island and have reached the limit of our landscape" (Quinn, 2015).

In NZ, regional and local councils play an important role in how farmers use their land, essentially acting as gatekeepers and enforcers for NZ's natural resources. NZ's regional councils are commissioned by the central government to enforce the Resource Management Act 1991 (RMA), under which, the regional councils manage and promote the sustainable management of natural resources and hold the authority for granting resource consents for any proposed changes in land use, including the establishment of irrigation systems. (Ministry for the Environment, n.d.) As dairy farming requires the exploitation of natural resources, the enforcement and structure of the RMA have had a significant influence on Fonterra's production output and growth.

In the years since the creation of Fonterra, it is the arid plains of the Canterbury region that has experienced some of the biggest changes as a result of the RMA and its implementation by the Canterbury regional council (Statistics NZ, 2019e) (Statistics NZ, 2018). As discussed in section 1.8, irrigation has transformed some of NZ's arid land into productive pastures as a direct result of resource consents being approved under the RMA. According to Canterbury regional council statistics, the Canterbury region has the highest water use in NZ, the most agricultural land being irrigated (64 per cent of all irrigated land is in Canterbury), and has been estimated to use 70 per cent of all water consumed in the region for irrigation (Canterbury Regional Council, 2020). The implication and interpretation of the RMA in Canterbury has enabled dairy farming to become feasible through the irrigation of arid land, thus contributing to the growth of Fonterra and the degradation of NZ's freshwater.

2.6 The impact of dairy intensification from different perspectives

Freshwater overexploitation and degradation are seen differently depending on where a stakeholder's interests lie. For the NZ government, it needs to protect freshwater from degradation for many reasons, not least for the sake of NZ's second-biggest industry, tourism, which uses the 'clean green' image of NZ's lakes and mountains in its overseas marketing campaigns (Ministry for foreign affairs and trade, 2017) (Tourism NZ, 2019). However, the government cannot ignore dairy farming's massive contribution to the national economy, therefore it needs to appease both industries (Ministry for foreign affairs and trade, 2017). This tactic can be seen in a 2005, Ministry for the Environment report into a proposed expansion of the Mackenzie Basin irrigation scheme. The report concluded that although there was a significant risk to ground and surface water contamination, any visual changes to the unique ecological character of the region would be hidden from the main motorways, minimising the impact on visitors to the region (Brown & Harris, 2005). Furthermore, by enabling further intensification of agriculture, it would positively impact the social structure of the region, by providing much-needed employment (Brown & Harris, 2005). In this instance, the government acknowledges the negative effects an irrigation expansion will have on water and the ecological characteristics of the region while justifying the project due to economic benefits and its presence been hidden from tourists. However, this approach is not always taken. 'Our fresh water 2017', was a stand-alone report by the Ministry for the Environment, which evaluated the state of freshwater in NZ (Ministry for the Environment, Stats NZ, 2017). The report was the first dedicated report into New Zealand's fresh water and was to be used as a baseline to track change over time (Ministry for the Environment, Stats NZ, 2017). The report concluded that the N levels in both ground and surface water were worsening at more testing sites (55 per cent) than those improving (28 per cent); sediment levels had increased due to human activity; native fish and invertebrate species were facing increasing pressure from human activity (Ministry for the Environment, Stats NZ, 2017). The scope of 'Our fresh water 2017' focused solely on the state of fresh water in NZ. As such, it could deliver its conclusion without the need to consider economic implications, delivering a transparent conclusion and implicating dairy farming as the worst offender of all industries in NZ.

The 2017 report by the OECD gives an international evaluation of NZ's freshwater management (OECD, 2017). The report covers NZ's efforts to get environmental policies into the mainstream, the management of freshwater, sustainable urban development, environmental performance and the management of the environment by governmental agencies. While the report describes New Zealand as having strengthened its environmental policies since its last report in 2007, it goes on to say that NZ's growth model had 'started to show its environmental limits', and had increased its GHG emissions, freshwater contamination and threats to biodiversity. (OECD, 2017)

The report was highly critical towards the slow progress being made by successive NZ governments to rein in GHG emissions and the pollution of freshwater. GHG emissions from NZ had increased by 6% since 2010, half of which were caused by agriculture, the highest in the OECD. The 6% increase contrasts to a 5% average reduction for the rest of the OECD. Another concern was the NZ governments continued support of irrigation in agriculture, where it was estimated to consume 75% of all water used in NZ. The report recommended the introduction of water charges, to change how the resource is being utilised, as currently, commercial water users were not paying society for the benefit they receive. (OECD, 2017)

From Fonterra's perspective, their first sustainability report in 2017 was an acknowledgement of the impact they were having on freshwater and the environment in general. As can be expected from a self-produced report, it conveys a generally optimistic tone, highlighting positive achievements and ambitions concerning the environment and sustainable dairying practices (Fonterra Dairy Co-operation Ltd., 2018). There is some lack of perspective when presenting statistics though, one example being the fact that NZ produces the lowest GHG emissions per litre of milk collected in the world, demonstrating the efficiency gained through research into cattle breeds and the effects of diet on gas production. However, despite the efficiency of the NZ dairy industry, its overall production of GHG's is still the worst in the OECD (OECD, 2017)

The report highlights the work done by Fonterra to fence off all permanently defined waterways, to stop cattle excreting directly into waterways and to protect riverbanks from erosion caused by grazing cattle. Planting along river and stream banks has also been encouraged, which helps filter sediment and prevents erosion. By May 2017, 98.7 per cent of waterways on Fonterra's supplying farms have been fenced to keep cows out, with 99.8 per cent of all crossings having bridges or culverts built. Fonterra has also pledged NZ$20 million over the next ten years to their 'Living Water partnership' with the NZ Department of conservation, where they plan to demonstrate that sustainable dairy farming is possible through the scaling up of innovative means to increase ecological resilience. (Fonterra Dairy Co-operation Ltd., 2018)

To the uninformed, this report conveys a company which is both sustainable and ethical. To someone who has read the reports by the OECD and the Ministry for the environment, the report might seem somewhat misleading (OECD, 2017) (Ministry for the Environment, Stats NZ, 2017). Despite Fonterra's efforts to plant riparian strips, fence waterways, donate money to help clean up waterways and breed cattle that produce less GHG's, the fact is that both sediment and N from dairy farming are increasing in waterways. The cost of removing N above safe levels from drinking water would cost billions annually and the NZ dairy industry is the worst emitter of GHGs in the OECD (Foote, 2014) (OECD, 2017) (Ministry for the Environment, Stats NZ, 2017). The remedial work presented by Fonterra, while perhaps well-intentioned, ignores issues relating to its production capacity outgrowing NZ's environmental limitations, instead implementing fixes that will merely slow the rot.

2.7 Summary and research question

In summary, Weber, Naumann along with their contemporaries Dokulil and Teubner, defined how nutrient enrichment of freshwater can change its trophic state. Nutrient enrichment of freshwater in the form of N and P was shown to be caused by excessive fertiliser application to pastures, soil erosion and from the excretion of cattle, with all three causes coming as a direct result of dairy farming activities. Furthermore, water scarcity in NZ is being exacerbated by the 4.8 billion litres used annually by the dairy industry. Additionally, Fonterra's main input of milk production, cattle, has been proven to be a major source of E. coli.

As the researcher considers the dairy industry's growth to be at the core of freshwater degradation, macro-environmental factors that enabled growth were examined. Government regulation and its management by regional councils were shown to be major enablers of growth. Additionally, the FTA between NZ and China created an unprecedented demand for milk products, becoming the biggest growth driver for Fonterra. While it is widely accepted that intensive dairy farming over-exploits both land and freshwater to the detriment of both, the researcher is unaware of any existing research into Fonterra's influence on dairy farming intensification. Therefore, this thesis will ask the question: To what extent has the creation of Fonterra facilitated the pollution and over-exploitation of fresh water?

3. Analysis

3.1 Analytical framework

The analysis will be based on quantitative research, whereby secondary data will be used to determine the outcome of the thesis question. Secondary data was chosen, as the NZ government provides large scale, high quality, nationally representative data sets, which would not otherwise be practical for the researcher to collect. The data sets to be analysed represent the aspects of dairy farming which have negatively affected freshwater the most. The indicators to be analysed are the ratio of dairy cattle per hectare of land; the amount of nitrogen fertiliser used by the dairy industry over time; nitrogen runoff from dairy farming; and the area of land being irrigated in NZ over time. The analysis will look for trend changes after 2001, the year Fonterra was created, to determine if the creation of Fonterra has worsened or at least coincided with an acceleration of freshwater degradation.

3.2 Limitations

The analysis looks at statistics at a national level, which does not distinguish between regional differences, distributing some of the more extreme regional statistics over the whole country, losing some perspective in the process.

3.3 Stocking rates of dairy cattle per hectare of land

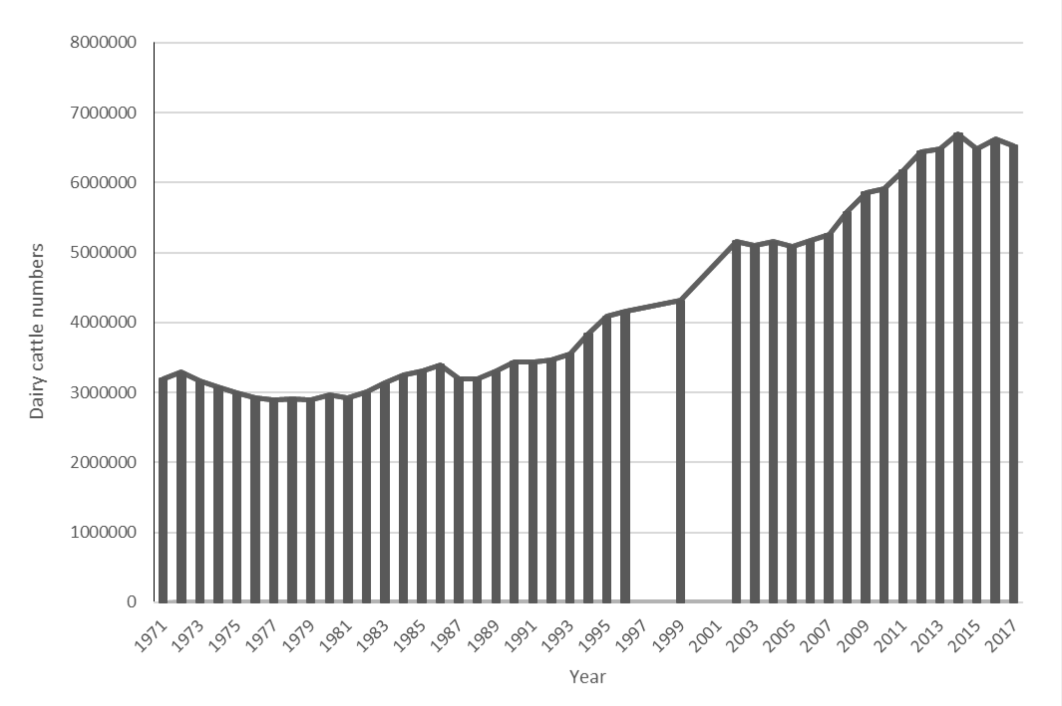

Figure 7. New Zealand's dairy cattle numbers *1971-2017 (Statistics NZ, 2019e). * No data available for 1997,1998,2000 and 2001)

In Figure 7, dairy cattle numbers remained relatively stable between 1971 and 1984, with 3.2 million dairy cattle in 1971, slightly fewer numbers in the years between due to the UK joining the EEC causing a reduction in demand, however, returning to 3.2 million by 1984 (Evans, 2004) (Statistics NZ, 2019e). In 1985, 16 years before Fonterra was created, NZ's dairy cattle numbered 3.3 million (Statistics NZ, 2019e). By 2002, the year after Fonterra's creation (October 2001), dairy cattle in NZ numbered 5.2 million, a 56% increase since 1985 (Statistics NZ, 2019e). In 2017, 16 years after the creation of Fonterra, dairy cattle in NZ numbered 6.5 million, a further increase of 27% (Statistics NZ, 2019e).

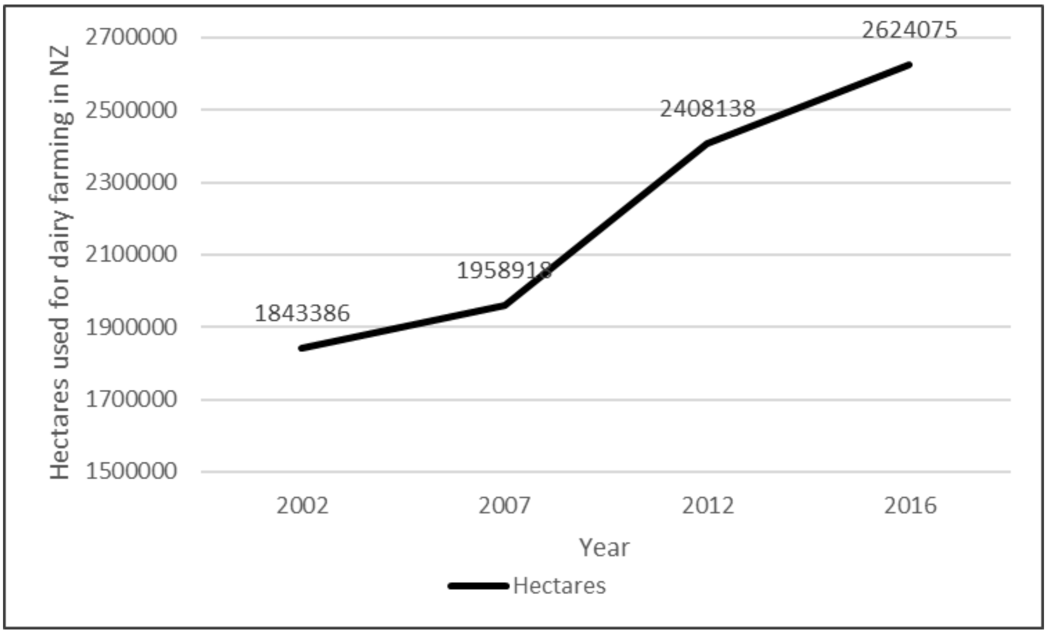

Figure 8. Hectares of land used for dairy farming in New Zealand. (Statistics NZ, 2018)

While land-use data pre-dating Fonterra's creation was not available to the researcher, it can be observed in Figure 8 that the land used for dairy farming since Fonterra's creation has increased in area. From 1,843,386 hectares in 2002, to 2,624,075 hectares in 2016, an increase of 42% (Statistics NZ, 2018). The higher growth rate between 2007 and 2012 was most likely a response to the 2008 free trade agreement signed between China and NZ, which created an increased demand for milk products. Therefore, more land was required to increase production (Statistics NZ, 2016).

Year			Cows per hectare
2002	Hectares	1843386	2.8
	Dairy Cattle	5161589	
2007	Hectares	1958918	2.7
	Dairy Cattle	5260850	
2012	Hectares	2408138	2.7
	Dairy Cattle	6445681	
2016	Hectares	2624075	2.5
	Dairy Cattle	6618800	

Table 1. Showing changes in the stocking rate of NZ dairy farms from 2002,2007, 2012 and 2016. (Statistics NZ, 2018) (Statistics NZ, 2019e)

As seen in Table 1, stocking rates on NZ dairy farms have on average reduced from 2.8 head of dairy cattle per one hectare of land in 2002 to 2.5 head of dairy cattle per one hectare of land in 2016, a 12 per cent reduction (Statistics NZ, 2018) (Statistics NZ, 2019e). The pressure of carrying more stock per hectare has been reduced during Fonterra's period of market dominance. However, the overall growth in cattle numbers and land being used for dairy is likely to offset the lower stocking rate. As a point of reference, the stocking rates in Ireland, which has a similar pasture-fed dairy industry to NZ has an average stocking rate of 1.9 head of dairy cattle per one hectare of land (Humphreys, et al., 2019).

3.4 The use of fertiliser on dairy farms

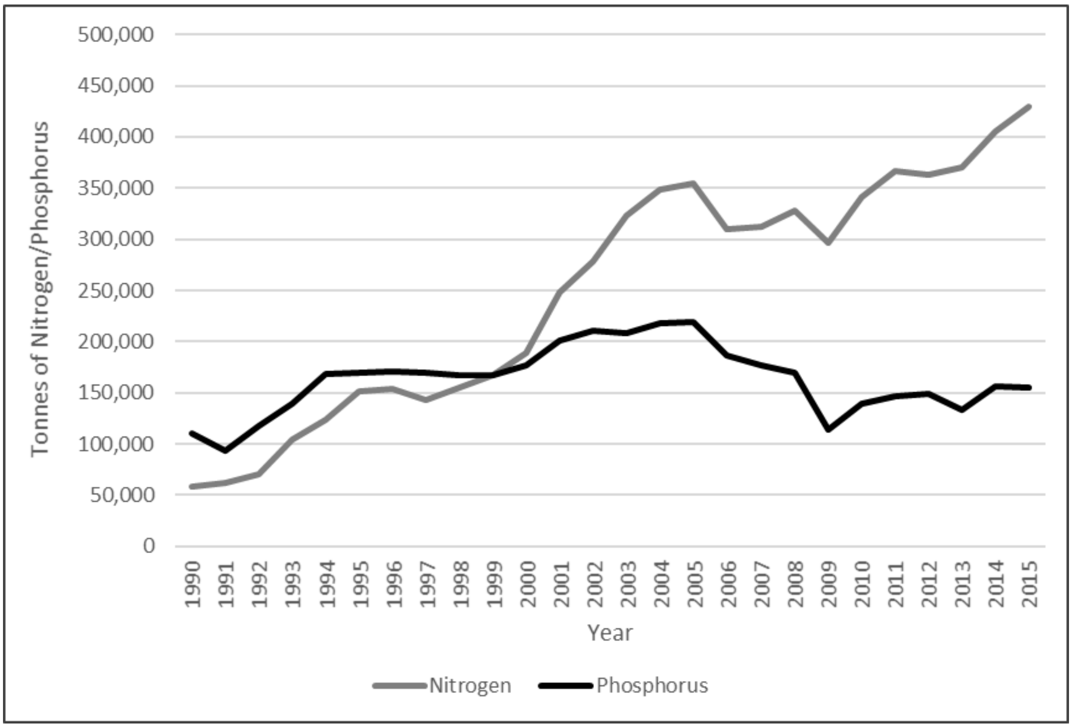

Figure 9. Tonnes of nitrogen and phosphorus used on NZ dairy farms between 1990-2015 (Statistics NZ, 2019b).

A drastic difference in the way fertiliser has been used, both pre- and post-Fonterra's creation can be observed in figure 9. From 1990 to 1998 more P than N was used (Statistics NZ, 2019b). In 1999 N and P usage was equal before N became the most used fertiliser in 2000 (Statistics NZ, 2019b). In the ten years prior to Fonterra, use of N more than tripled, and continued to increase afterwards, by almost half again in the following decade (Statistics NZ, 2019b). The reduction in both N and P in 2009 was due to a severe drought, high fertiliser prices and a period of low income reducing demand for fertiliser (Ministry for Primary Industries, 2012).

Year	2002	2007	2012	2016
Kg of nitrogen/hectare	151	159	151	163
Kg of phosphorus/hectare	114	90	62	59

Table 2. Kg of nitrogen and phosphorus used per hectare of land used for dairy farming. (Statistics NZ, 2019b) (Statistics NZ, 2018)

The ratio of N and P used for every hectare dairy farming land in NZ can be seen in Table 2. Since Fonterra's creation, P loading has been reduced in a linear trend to around half of its 2002 value in 2016, N loading has increased overall, however, the small size of the data set means that a definitive trend cannot be observed. (Statistics NZ, 2019b) (Statistics NZ, 2018)

3.5 Nitrogen runoff from dairy farms

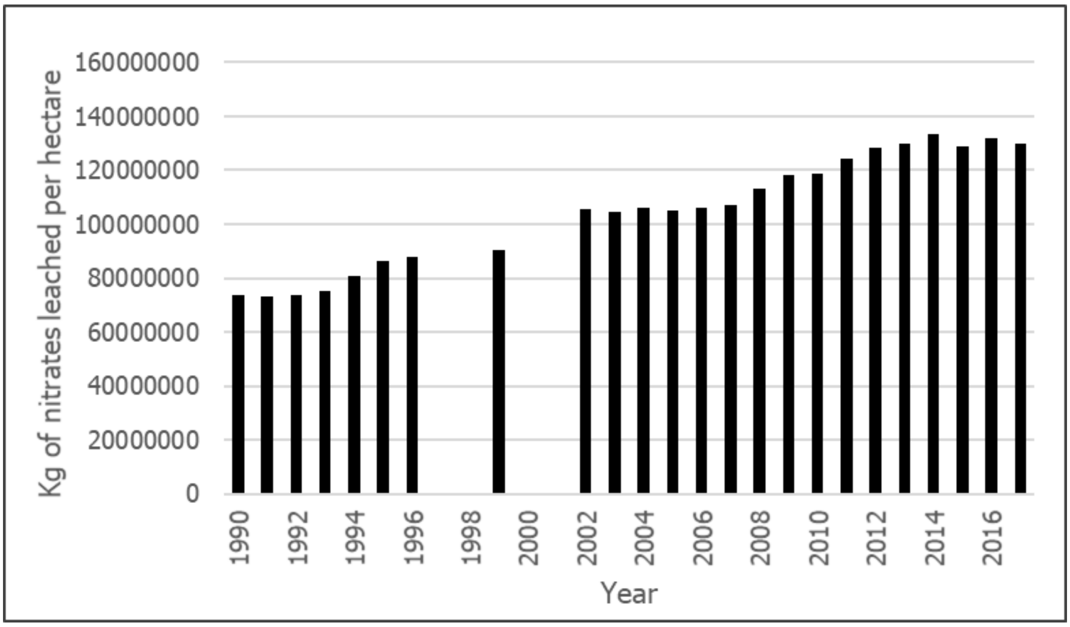

Figure 10. Kilograms of nitrates leached per hectare of land used for dairy farming. (Statistics NZ, 2019c) * No data available for 1997,1998,2000 and 2001)

As seen in Figure 10, N leaching from land used for dairy farming has been increasing since 1992, with the exception of 2003 to 2006, where leaching rates remained static. It can also be observed that after reaching its peak in 2014, the leaching rate has plateaued, although more data is required to see if this is a long-term trend. The lack of data from 1997, 1998, 2000 and 2001 makes it difficult to see if there was a significant change in N leaching post-Fonterra's creation, or if the rate of increase remained similar to that of pre-Fonterra. (Statistics NZ, 2019c)

3.6 Land area being irrigated over time

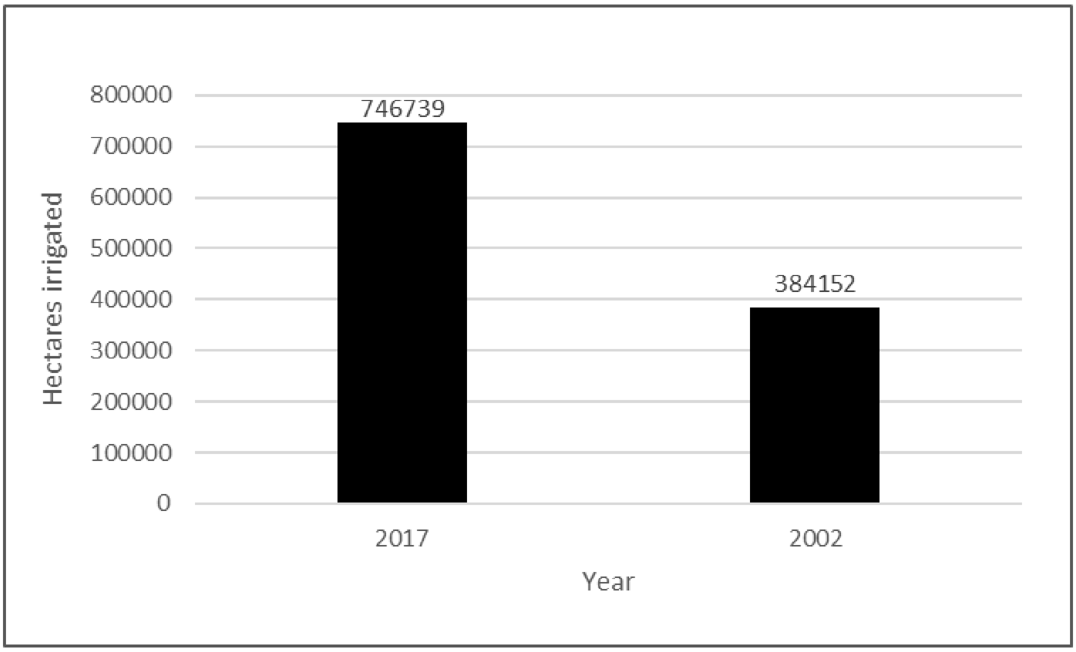

Figure 11. Total hectares of land being irrigated in NZ in 2017 and 2002. (Statistics NZ, 2019a)

Figure 11 shows a significant growth in the area of land being irrigated when comparing 2002 and 2017. Irrigated land has almost doubled between 2002 and 2017, from 384,000 hectares and 747,000 hectares, an increase of 94 per cent. (Statistics NZ, 2019a)

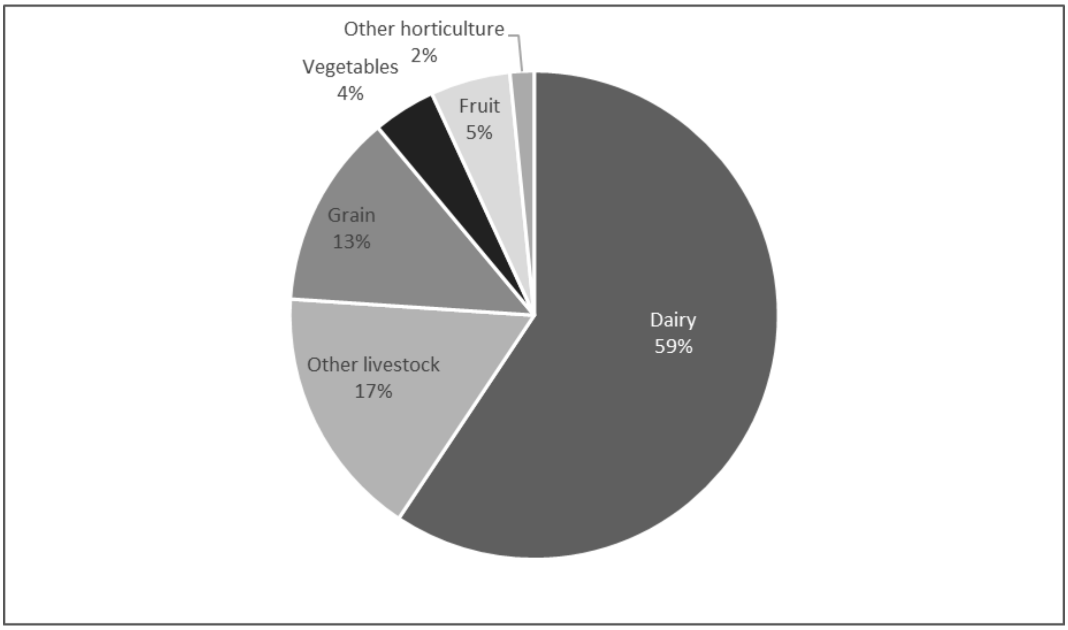

Figure 12. Irrigated land in 2017 separated into land use. (Statistics NZ, 2019a)

As seen in Figure 12, dairy farming is responsible for irrigating the most land in NZ, with 59 per cent, more than all other land uses combined. No data separating irrigated land by the type of land use is available for 2002. (Statistics NZ, 2019a)

3.7 Discussion and further analysis

The statistical analysis reveals an industry which has continued to grow rapidly since the early 1990s, through the creation of Fonterra in 2001 and beyond. Surprisingly, the intensity of which each hectare of land is fertilised and stocked with cattle has seen little change since 2001. Furthermore, the growth rate of the dairy cattle population has been reduced since Fonterra's creation. This would seem to indicate, at least in part, that despite having near absolute dominance of the NZ dairy industry, and no meaningful domestic competition, the intensity of which land and water are used has not increased since Fonterra was allowed to operate as a monopsony. These results reveal that the ten years prior to Fonterra's creation, to be a period of significant expansion for the dairy industry, however, with the single desk export and marketing board still in place, and the Chinese market yet to be fully opened to NZ's exporters, the question of what initiated this growth should be addressed.

The evidence seems to point to the economic upheaval experienced in NZ during the 1980s. Roger Douglas's market reforms, which in 1985 withdrew subsidies and almost all other support from agriculture, fully exposed NZ's dairy farmers to market competition in the global marketplace (Jay, 2006). The market exposure to international changes, where perceived by many as a threat to survival, creating anxiety that drove countermeasures to competition which involved growth, efficiencies of production, economies of scale, scientific and technological innovation and commercial superiority (Jay, 2006). The lack of subsidies forced the market to react, forcing farmers from other sectors to look into dairy farming as a means of diversification, creating an incentive for mergers between cooperatives and changing the mentality of farmers to one that seeks high productive output without considering the negative outcomes. It can perhaps then be said, that it is the legacy of the market reforms of the 1980s that have cumulatively led to the NZ dairy industry's cost led production methods, encouraging farmers to exploit the resources available to them to their fullest potential, and according to Mairi Jay, creating a culture of farmers measuring success by their levels of production (Jay, 2006).

3.8 Conclusion

This statistical analysis of the NZ dairy industry's actions and trends that have negatively affected freshwater in NZ revealed several reasons why the condition of NZ's freshwater is worsening, while at the same time showing that in some aspects, land is being used less intensively since the creation of Fonterra. It was observed that stocking pressure on land per hectare has reduced during Fonterra's existence, as the increase in stock numbers has not kept pace with the area of land being used for dairy farming. Furthermore, the expansion of land being used for dairy farming appears to have plateaued, however, more monitoring overtime is needed to see if this is a long-term trend.

The year on year growth rate of N fertiliser use has decreased since Fonterra's creation. However, due to the growth in the land area being used for dairy farming, the total quantity of N fertiliser being used has continued to grow. Both the increase in stock numbers and increases in N fertiliser being used is reflected in statistics showing increases in N leaching into waterways. Nevertheless, the rate of increase in N leaching is similar to those of pre-Fonterra. Finally, it has been shown that irrigation has drastically increased since Fonterra's creation, with dairy farming accounting for more irrigated land than all other agricultural industries combined.

4. References

Ainge Roy, E., 2020. *Auckland set to break record for longest-ever spell without rain.* [Online]
Available at: <https://www.theguardian.com/world/2020/feb/14/auckland-set-to-break-record-for-longest-ever-spell-without-rain>
[Accessed 12 April 2020].

Albrecht, G., 2005. 'Solastalgia' A New Concept in Health and Identity. *Philosophy, Activism, Nature ,* pp. 41-53.

Ansari, A. A., Gill, S. S., Lanza, G. R. & Rast, W., 2011. *Eutrophication: Causes, Consequences and Control.* s.l.:Springer.

Ball, A., 2006. *Estimation of the burden of water-borne disease in New Zealand: Preliminary Report,* Wellington: Ministry of Health.

Ballingall, J. & Pambudi, D., 2017. *Dairy trade's economic contribution to New,* Wellington: NZ Institute of Economic Research.

Beukes, P. C. et al., 2012. The relationship between milk production and farm-gate nitrogen surplus for the Waikato region, New Zealand. *Journal of Environmental Management,* pp. 44-51.

Bloomer, D., Curtis, A. & Reese, P., 2015. *Irrigations Development,* s.l.: Irrigation New Zealand.

Bridgeman, D., 2019. *Fonterra to sell Beingmate shares at huge loss.* [Online]
Available at:
<https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12256358>
[Accessed 6 April 2020].

Britton, E., Hales, S., Venugopal, K. & Baker, M., 2010. Positive association between ambient temperature and salmonellosis notifications in New Zealand, 1965-2006.. *Australian and New Zealand Journal of Public Health,* pp. 126-129.

Brown, I. & Harris, S., 2005. *Environmental, Economic and Social Impacts of Irrigation in the Mackenzie Basin,* Wellington: Ministry for the Environment.

Cameron, K. C., Di, H. J. & Moir, J. L., 2013. Nitrogen losses from the soil/plant system: a review. *Annals of Applied Biology 162,* pp. 145-173.

Canterbury Regional Council, 2018. *Annual Groundwater Quality Survey,* Christchurch: Canterbury Regional Council.

Canterbury Regional Council, 2020. *Canterbury region water quality.* [Online]
Available at: <https://www.lawa.org.nz/explore-data/canterbury-region/water-quantity/> [Accessed 6 March 2020]

Clarke, H. & Sutton, J., 2001. *Cabinet approves merger waiver 1/15.* [Online] Available at: <https://www.beehive.govt.nz/feature/global-dairy-company-cabinet-approves-merger-waiver-115>
[Accessed 28 March 2020].

Dairy NZ, 2013. *Nutrient management on your dairy farm.* Hamilton: Dairy NZ.

Dairy NZ, 2019. *Quick stats about dairying - NEW ZEALAND,* Hamilton: Dairy NZ.

Destremau, K. & Siddharth, P., 2018. *How does the dairy sector,* Wellington: NZ Institute of Economic Research .

Eckard, R. J., Grainger, C. & De Klein, C. A. M., 2010. Options for the abatement of methane and nitrous oxide from ruminant production: A reveiw. *Livestock Sciencs 130,* pp. 47-56.

Environment Waikato, 2008. *The condition of rural water and soil in the Waikato region: risks and opportunities,* Hamilton: Environment Waikato.

Evans, L., 2004. *Structural Reform: the Dairy Industry in New Zealand,* Wellington: New Zealand Institute for the study of competition and regulation.

Fondation Hëllef fir d'Natur, 2020. *Cattle trampling.* [Online] Available at: <https://www.unio.lu/risk/erosion-and-fine-sediments/cattle-trampling/> [Accessed 28 February 2020]

Fonterra Dairy Co-operation Ltd., 2018. *Fonterra sustainability report 2018,* Auckland: Fonterra.

Fonterra Dairy Cooperative, 2018. *Fonterra Annual Report 2018.* [Online] Available at: <https://www.fonterra.com/content/dam/fonterra-public-website/phase-2/new-zealand/pdfs-docs-infographics/pdfs-and-documents/financial-results/fy19/Fonterra-Annual-Report-2018.pdf> [Accessed 2 April 2020]

Fonterra Dairy Cooperative, 2019. *Fonterra Annual Report 2019,* Auckland: Fonterra Dairy Cooperative.

Fonterra Dairy Cooperative, 2020. *About. [online].* [Online] Available at: <https://www.fonterra.com/nz/en/about.html> [Acessed 14 April 2020]

Foote, K. J., 2014. *The Cost of Milk: Environmental Deterioration vs. Profit in the New Zealand Dairy Industry,* Palmerston North: Massey University.

Gilmour, S., 1992. *History of the New Zealand Milk Board: A study of the corporatist alliance between the state and the domestic milk sector,* Lincoln, New Zealand: Agribusiness & Economics Research Unit, Lincoln University.

Gorman, P., 2019. *High E coli bacteria levels at Queenstown Bay.* [Online] Available at: <https://www.stuff.co.nz/national/109758301/high-e-coli-bacteria-levels-at-queenstown-bay> [Accessed 12 February 2020]

Gray, J., 2017. *Fonterra boss: 'I am angry and disappointed' over $183 million payout.* [Online]
Available at: <https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11951198>

Humphreys, J., Barrett, . D. & Fenger, F., 2019. Optimum stocking rate on the grazing platform. *Irish Dairying: Growing sustainably,* pp. 138-139.

Index Mundi, n.d. *New Zealand Palm Kernel Meal Imports by Year.* [Online] Available at: <https://www.indexmundi.com/agriculture/?country=nz&commodity=palm-kernel-meal&graph=imports> [Accessed April 10 2020]

Ishler, V. A., 2016. *Nitrogen, Ammonia Emissions and the Dairy Cow.* [Online] Available at: https://extension.psu.edu/nitrogen-ammonia-emissions-and-the-dairy-cow [Accessed 7 March 2020].

Jay, M., 2006. *The political economy of a productivist,* Hamilton: University of Waikato.

Johnston, K., 2013. *North Island drought worst in history.* [Online] Available at: <http://www.stuff.co.nz/ipad-editors-picks/8405004/North-Island-drought-worst-in-history>
[Accessed 28 March 2020].

Kitto, J., 2018. *Water use 'drop in ocean' compared to rainfall.* [Online] Available at: <https://www.dairynznewslink.co.nz/community/water-use-drop-in-ocean-compared-to-rainfall>
[Accessed 17 March 2020].

Macara, G. R., 2016. *Climate and weather of Canterbury,* s.l.: NIWA.

MacManus, J. & Nadkarni, A., 2019. *NZ's biggest greenhouse gas emitters and their struggle to pollute less.* [Online]
Available at: <https://www.stuff.co.nz/business/114431409/nzs-biggest-greenhouse-gas-emitters-and-their-struggle-to-pollute-less>
[Accessed 11 April 2020].

Ministry for foreign affairs and trade, 2017. *Goods and services trade.* [Online] Available at: <https://www.mfat.govt.nz/assets/Trade/Trade-stats-and-economic-research/Goods-and-Services-Trade-YE-March-2017.pdf> [Accessed 5 March 2020]

Ministry for Primary Industries, 2012. *PASTORAL INPUT TRENDS IN NEW ZEALAND: A SNAPSHOT,* Wellington: Ministry for Primary Industries.

Ministry for the Environment and Stats NZ (2), 2019. *Environment Aotearoa 2019,* Wellington: Ministry for the Environment.

Ministry for the Environment, Stats NZ, 2017. *Our Fresh Water 2017,* Wellington: The New Zealand Ministry for the Environment.

Ministry for the Environment, 2010. *Agriculture Emissions Projections provided by Ministry of Agriculture and Forestry,* Wellington: Ministry for the Environment.

Ministry for the Environment, n.d. *Resource Management Act 1991.* [Online] Available at: <https://www.mfe.govt.nz/rma> [Accessed 10 April 2020]

Ministry of Foreign Affairs and Trade, 2008. *New Zealand – China Free Trade Agreement: National Interest Analysis,* Wellington: Ministry of Foreign Affairs and Trade.

Ministry of Health, 2008. *Drinking-water Standards for New Zealand 2005 (Revised 2008),* Wellington: Ministry of Health.

Mitchell, C., 2018. *NZ can't shake its dangerous addiction to West Saharan phosphate.* [Online]
Available at: <https://www.stuff.co.nz/business/farming/106331828/nz-cant-shake-its-dangerous-addiction-to-west-saharan-phosphate>
[Accessed 28 March 2020].

Naumann, E., 1919. Några synpunkter angående limnoplanktons ökologi med särskild hänsyn till fytoplankton. *Svensk Botanisk Tidskrift,* pp. 129-163.

New Zealand Parliament, 2001. *Dairy Industry Restructuring Act 2001.* [Online] Available at: <http://www.legislation.govt.nz/act/public/2001/0051/latest/whole.html#DLM106751> [Accessed March 12 2020]

Norgate, C., 2013. *Proposed Acquisition of Warrnambool Cheese and Butter Factory Company Holdings Limited,* s.l.: Australian Competition Tribunal.

NZ fish and game, 2019. *NZ fish and game.* [Online] Available at: <https://fishandgame.org.nz/assets/Uploads/Colmar-Brunton-Survey-for-Fish-Game-NZ-Kiwis-Biggest-Concerns-Embargoed-6pm-Jan-2-2019.pptx> [Accessed 22 March 2020]

NZ Government, 2001. *Government sends letter to dairy farmers.* [Online] Available at: <https://www.beehive.govt.nz/node/10854>[Accessed 15 March 2020]

OECD, 2017. *OECD Environmental Performance Reviews; New Zealand 2017,* s.l.: s.n.

Paddy, L., Satherley, D. & Tukia, A., 2019. *E.coli found in Christchurch water.* [Online] Available at: <https://www.newshub.co.nz/home/new-zealand/2019/12/e-coli-found-in-christchurch-water.html>
[Accessed 10 March 2020].

Pangborn, M. & Woodford, K., 2011. *Canterbury dairying - a study in land use change and increasing production,* Lincoln: Lincoln University, New Zealand.

Parliament, NZ, 1923. *Dairy-produce Export Control Act 1923.* Wellington: s.n.

Pinares-Patiño, C., Waghorn, G., Hegarty, R. & Hoskin, S., 2009. Effects of intensification of pastoral farming on greenhouse gas emissions in New Zealand. *New Zealand Vetenary Journal,* pp. 252-261.

Pruimboom-Brees, I. M. et al., 2000. *Cattle lack vascular receptors for Escherichia coli O157:H7 Shiga toxins,* Ames: Veterinary Medical Research Institute.

Quinn, H., 2015. *Trading with a Giant: The Implications of New Zealand's Free Trade Agreement with China,* Wellington: Victoria University.

Schewe, J. et al., 2013. *Water scarcity and climate change,* s.l.: Proceedings of the National Academy of Sciences of the United States of America.

Selbie, D., Buckthought, L. E. & Shepherd, M., 2015. The challenge of the Urine Patch for Managing Nitrogen in Grazed Pasture Systems. *Advances in Agronomy,* pp. 229-292.

Statistics NZ, 2016. *Stats NZ.* [Online] Available at: <https://www.stats.govt.nz/reports/trade-with-china-nearly-tripled-in-past-decade> [Accessed 6 April 2020]

Statistics NZ, 2018. *Agricultural land use data.* [Online] Available at: <https://statisticsnz.shinyapps.io/agricultural_landuse/> [Accessed 15 March 2020]

Statistics NZ, 2019a. *Irrigated Land.* [Online] Available at: <https://www.stats.govt.nz/indicators/irrigated-land> [Accessed 20 February 2020]

Statistics NZ, 2019b. *Nitrogen and phosphorus in fertilisers.* [Online] Available at: <https://www.stats.govt.nz/indicators/nitrogen-and-phosphorus-in-fertilisers> [Accessed 21 March 2020]

Statistics NZ, 2019c. *Nitrate leaching from livestock.* [Online] Available at: <https://www.stats.govt.nz/indicators/nitrate-leaching-from-livestock> [Accessed 15 March 2020]

Statistics NZ, 2019d. *Lake water quality.* [Online] Available at: <https://www.stats.govt.nz/indicators/lake-water-quality>[Accessed 15 March 2020]

Statistics NZ, 2019e. *Livestock numbers.* [Online] Available at: <https://www.stats.govt.nz/indicators/livestock-numbers> [Accessed 15 March 2020]

Statistics NZ, 2020b. *China top trade partner for 2019.* [Online] Available at: <https://www.stats.govt.nz/news/china-top-trade-partner-for-2019> [Accessed 5 March 2020]

Statistics NZ, n.d. *About us. [online].* [Online] Available at: Available at: <https://www.stats.govt.nz/about-us/> [Accessed 16 April 2020]

Stewart, K. M., 1967. *Eutrophication - a Review,* Sacramento: State water quality control board.

Sutton, J., 2001. *GLOBAL DAIRY COMPANY - CABINET APPROVES MERGER WAIVER 2/15.* [Online]
Available at: <https://www.beehive.govt.nz/feature/global-dairy-company-cabinet-approves-merger-waiver-215>
[Accessed 28 March 2020].

Taylor, R. et al., 1997. *The State of New Zealand's Environment,* Wellington: Ministry for the Environment.

The United Nations: Department of Economic and Social Affairs, 2019. *World Population Prospects 2019,* s.l.: United Nations.

Thiennemann, A., 1918. *Untersuchungen über die Beziehungen zwischen dem Sauerstoffgehalt des Wassers und der Zusammensetzung der Fauna in norddeutschen Seen,* s.l.: s.n.

Tockner, K. & Likens, G. E., 2009. *Encyclopedia of Inland Waters, Volume 1.* s.l.:Academic Press.

Tourism NZ, 2019. *What we do.* [Online]
Available at: <https://www.tourismnewzealand.com/about/what-we-do/campaign-and-activity/> [Accessed 10 April 2020]

Trechter, D., McGregor, M. & Murray-Prior, R., 2003. *A Neo-Institutional Assessment of Cooperative Evolution: Comparing the Australian Wheat Board and the Fonterra Dairy Group.* Kansas City, s.n., p. 5.

van Battum, S. & Ledman, M., 2019. *Global Dairy Top 20,* s.l.: Rabobank.

Weber, C. A., 1907. Aufbau und Vegetation der Moore Norddeutschlands. *Beiblatt zu den botanishchen jahrbuchern. nr 90*, pp. 19-34.

Workman, D., 2020. *Top Milk Exporting Countries.* [Online]
Available at: <http://www.worldstopexports.com/top-milk-exporting-countries/>
[Accessed 6 April 2020].

World Health Organisation, n.d. *Water sanitation hygien.* [Online]
Available at: <https://www.who.int/water_sanitation_health/diseases-risks/diseases/methaemoglob/en/> [Accessed 27 February 2020]

World wide fund for nature, n.d. *Palm Oil.* [Online]
Available at:
<https://wwf.panda.org/our_work/food/sustainable_production/palm_oil/> [Accessed 10 April 2020]