

Dairy Farming, Climate Change and Farm Diversification



Amber Carpenter Course 39 2019 I wish to thank the Kellogg Rural Leadership Programme Partners and Sponsors for their continued support:

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Executive Summary

All across the world, in every kind of environment and region known to man, increasingly dangerous weather patterns and devastating storms are abruptly putting an end to the long-running debate over whether or not climate change is real. Not only is it real, it's here, and its effects are giving rise to a frighteningly new global phenomenon: the manmade natural disaster. (Barack Obama, speech, Apr. 3, 2006)

In the race against climate change, this report explores the possibilities of the diversification of a dairy platform into horticulture. This report was not put together to come up with an answer or find a solution, the purpose of this report is to start a topic of conversation, provoke thoughts and ideas and hopefully create some positive changes for the greater good for the future of our environment.

Throughout there report, there is a lot of work referenced by many individuals and companies that are doing some world-changing research in the space of land use change.

In this report, it is essential to note that Horticulture refers to Fruits, berries, vegetables, vineyards.

Agriculture produces nearly half of New Zealand's total greenhouse gas emissions with one-quarter of our total greenhouse gases coming from biological dairy emissions (Methane and Nitrous Oxide). 85% of the dairy sectors emissions are also made up on the farm, with the other 15% coming from agriculture transport and processing. When breaking emissions down within the agriculture sectors in 2017, around 78% of emissions come from Livestock, 21% from soils (fertiliser applications etc.) and the remaining 1% from urea and liming. (Emissions Tracker, 2019). New Zealand also has a unique greenhouse gas profile and is unusual for a developed country, we have one of the highest rates of emissions per person, and agricultural emissions dominate our emissions profile compared to the rest of the world where energy and fossil fuels dominate them. With the difference between New Zealand and the rest of the developed world, we could assume that no other country will look to combat methane or nitrous oxide, giving New

Zealand a chance to show our ingenuity and become world-leading at reducing these gases.

There has been vast research on the likely impacts of climate change in the future. All of these changes will impact our environment, our lifestyle, businesses and the economy. These impacts and changes in climate impact not only the Dairy Industry but all sectors and put pressure on the food production industry as a whole.

From several studies, results have shown that land use change into horticulture will reduce emissions and ensure maintaining lower emissions is sustainable in the future. One study prepared for Motu found that to reach our emissions targets for 2050 seems possible with no additional on-farm mitigation through new technology however if achieved without a shift towards horticulture, mitigation technology or permanent forestry then reductions would be difficult to sustain as forestry expansion is limited. With development into horticulture by one million hectares, results show the emission reductions are almost identical to those emission reductions from new technologies. By achieving a reduction through a combination of horticulture increase and new technologies, emissions will be more manageable in the future. (Dorner, Djanibekov, Soliman, Stroombergen, Kerr, Fleming, Cortes-Acosta, Greenhalgh. 2018).

A study around permanent horticulture was researched as an option for low emitting land use. Modelling work was done on a pip-tree crop, where an area of a farm was taken out to grow chestnuts. With changing the land use on a dairy farm to permanent horticulture, there is a decrease in greenhouse gas emissions as well as a positive impact on the farm businesses EBIT. While a change in land use to horticulture could be an option soil types, crops and regional climates need to be taken into consideration. (AgFirst, 2019).

Horticulture is currently planted on 190,000 hectares in New Zealand, and according to statistics established, horticulture operations have higher profitability per hectare than dairy operations ranging from \$5,000 to \$20,000 and above. (Resigner, Clark, Journeaux, Clark, Lambert, July 2017). Dairy operations have profitability of around \$2,500 per hectare. Currently, dairy is farmed on 2.6 million hectares (ha), fruits and berries 120,000ha, vegetables 70,000ha and grains 449,000ha (Stats NZ, April 2018). According to the reports referenced in this paper, the available land to go into horticulture is

anywhere between 1.5million and 3.2million hectares, taken from both dairy and sheep and beef. For dairy farmers to be able to diversify their current farming platform into horticulture, information is needed to understand what could grow best on their platform. During the time this paper was put together, from what I could find, and very much out of the scope of this report, there is no mapping around best soil types, climate and growing ability to help dairy farmers understand their potential. However, if this could be achieved, combined with the work done on how climate change will affect our landscape, these tools would open up opportunities to help dairy farmers convert land use.

From a value-add point of view to the end product of what we are producing, Customers and consumers are more interested in climate change and sustainability than ever. Terms such as Sustainable, Organic, Environmentally Friendly, all gain consumer confidence and support. There is a lot of awareness of the impact on the climate and a focus for consumers on where their food comes from, how it's produced, and consuming food that is healthy for them and healthy for the world (Philips, L. 2019).

Although the option to diversify a farm business into other primary sectors is very dependent on soil type, farm business and location. The idea of bringing sectors together onto the same sustainable platform which tells a story of bettering the environment fits into what consumers are looking for and wanting out of their produce.

For example, looking into the future where we can work out what emissions come from a dairy farm, have a full understanding of what emissions come from a crop or orchard and also what sequestration is achieved from this, what are the possibilities?

Take a farm that has reduced its stocking rate, worked on pasture management and in turn reduced overall emissions from the dairy platform. With the farms reduced stocking rate, they have been able to plant an avocado orchard on the land that has been freed up and dramatically reduce further or even offset the emissions from farm activities completely. "Carbon Neutral New Zealand Produce or Carbon Positive New Zealand Produce". How great would that look branded on the side of a bottle of milk or a bag of avocados?

In conclusion, climate change is a complex and continuously changing subject. The science and information around where climate change is today and how we are going to tackle this as a species is forever evolving as new information comes to light. There is a lot of evidence to suggest diversification into horticulture is not only beneficial to emissions but also potentially profitable. Although the research suggests these positive outcomes, it also notes that there is no one size fits all solution.

Every farm is different; every farmer is different. We range in farm size, herd size, systems, soil type, climate, profitability, infrastructure, and management.

If we can have a better understanding of what horticultural crop can be grown where, what will the emissions be from the growth of horticulture and what positive effects will come from diversifying into horticulture, the opportunity to future proof not only farm businesses in New Zealand from climate change but also the ability to market our collaboration and success of total carbon reduction could increase the value of our products further to the world.

At the moment we do know, New Zealand dairy farmers are already doing more than their bit in the reduction of greenhouse gases and will still do more to protect the environment and our planet from further damage.

There is an opportunity to come together as sectors, from the grassroots level to industry heads, to achieve this common goal and work together and support each other in how we are going tackle this "Titanic" problem.

We are the first generation to be able to end poverty and the last generation that can take steps to avoid the worst impacts of climate change. Future generations will judge us harshly if we fail to uphold our moral and historical responsibilities. (Ban, K. 2016)

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Introduction

Aotearoa, a land that defines us as a people, a land that needs our care. We are Kaitiaki¹ of this whenua, it's past, and it's future. Guardians of its unique biology because our land is our future (Manaaki Whenua, 2018).

New Zealand is our turangawaewae – it's our home, its who we are. We live in an exceptional and distinct part of the world with unique biodiversity, ecosystems and landscape. We have used this land to nourish us, shelter us and provide for us, but as we have used this land to our advantage, we have over time started altering our natural ecosystem (Environment Aotearoa, 2019). Human influence is changing the structure of our climate and in turn, changing our environment for the worst. Maori have a deep connection with Aotearoa and believe there is a kinship between humans and the natural world. They express this through kaitiakitanga or guardianship and protection. As New Zealanders we have an inherent value in us to do the right thing, it drives us to protect, nourish and fight for those that can't fight for themselves, for what is ours and for what we believe in. Kaitiakitanga is a value that as New Zealanders comes naturally to us, we are born with it. It is a value we need to hold onto, draw from and use to protect the future of our turangawaewae for future generations.

The issue of climate change is one of the most significant environmental challenges that our species has ever had to face. Whether or not you believe climate change is a natural cycle of the earths seasonal shift or human interference is the reason we are experiencing these catastrophic changes to our environment, something we can all agree on is it is happening. Climate change is here; we are experiencing the effects and its gaining momentum.

Kaitiakitanga - Guardianship

The land remains when people have disappeared. (Alsop, P & Kupenga, T.R, 2016)

¹ Kaitiaki – Guardians

With the continual and rapid change of our climate along with the impact it is having on our environment, farming systems and businesses, I want to explore the possibility of reducing climate change emissions through a diversified farming operation. As agriculture in New Zealand plays a significant role in our countries climate change emissions, the primary sectors, especially dairy, will be in the spotlight once more for environmental impacts. In this paper, I will look to explore the possibilities of integrating or diversifying a dairy farming business to include other primary sectors that may help to reduce or offset the climate change impacts a dairy farm creates on its own.

Methodology

The research used in this report involved a literature review, interviews and a survey with thematic analysis. The main component of my research was the literature review. I used this literature review to gain a better understanding on where climate change is today, what part agriculture and the dairy sector played as well as current and future mitigation options available to dairy farmers to reduce climate change impacts.

After extensive literature research, I interviewed several industry professionals around their involvement with climate change, agriculture, and what impact diversifying farming systems could have. To also get an understanding of Dairy Farmer's thoughts, feelings, and knowledge toward climate change in agriculture, I conducted an anonymous online survey which received 100 responses.

What is Climate Change

The Ministry for Primary Industries New Zealand explains Climate change "as a term used to describe long-term changes in global weather patterns that have:

- 1. Resulted from increased levels of certain gases in the atmosphere
- 2. Been caused by humans".

"It is caused by an energy imbalance in the earth's atmosphere. Temperature increases result when the amount of energy entering the atmosphere exceeds the amount of energy leaving the atmosphere" (Vivid Economics, March 2017). Earth's climate is a finely balanced system which has always warmed and cooled over time. The speed and extent of the warming or cooling depend on natural processes and now in most recent times human activities. Climate change for us today is being caused by a buildup of greenhouse gas emissions in our atmosphere. It is fair to note that greenhouse gases are a minor yet natural component of our atmosphere, and without them, the earth would be a lot cooler. If you were to remove the natural greenhouse gases from our atmosphere, the earth's temperature would drop from 15°C to negative 18°C making earth unsustainable for life. With them, our planet maintains a balanced ecosystem and life goes on in perfect harmony.

Where greenhouse gases have become an issue and are increasing earth's temperature at a rapid rate is primarily due to human activities. Science now shows with 95 % certainty that human activity is the dominant cause of observed warming since the mid-20th century (Ministry for the Environment & Stats NZ, 2017). Since the industrial revolution, human activities such as burning fossil fuels, changing land use and deforestation have increased the overall concentration of greenhouse gases in our atmosphere, causing global warming or what we now refer to as climate change. As the buildup of these gases occurs in our lower atmosphere, it causes the warming of the earth's surface. When air and water temperatures rise the warmer temperatures affect weather patterns causing increased frequency and severity of drought, floods, and storms. The scientific community has warned that if greenhouse gas emissions keep increasing, the planet will reach a point of no return. Climate change will become catastrophic and irreversible (World Economic Forum, 2019).

Background on Emissions

The term Greenhouse Gases came from the warming effect that the gases have on earth. Greenhouse gases are naturally occurring compounds and prevent heat from escaping our atmosphere; they act as an insulating blanket around the planet; hence term "The greenhouse effect".



Figure 1: The natural "greenhouse gas" process showing how the earth is kept at a desirable Temperature for sustainable living. Source DairyNZ

As the sun warms the earth, ice and clouds reflect some of the light away, the rest becomes absorbed by land and water and remitted as heat. A lot of that heat escapes up to space, and some are held in by our atmospheric layers. The insulating effect of the

natural greenhouse gas is the reason why life exists on earth as we know it.

So how do we know human activities are the result of increased concentration of greenhouse gases that are responsible for warming the earth? Our atmosphere has five layers. If the sun were responsible for our warming climate, we would see the warming effect happening in the upper and lower layers of our atmosphere together. What scientists have found is that warming is occurring in the lower layer of our atmosphere, the same place where human greenhouse gases are building up (Dairy NZ, 2018).

There are three major greenhouse gases which play a part in climate change because of their ability to absorb heat and the length of time they stay in the atmosphere. These are also directly influenced by human activities.

Carbon dioxide: (CO2) Carbon dioxide is produced in the extraction, production and use of fossil fuels – such as petrol and coal.

Methane: (CH4) Methane is produced by ruminant animals.

Nitrous oxide: (N2O) Nitrous oxide gas commonly comes from the conversions in the soil by microbes of nitrogen in fertiliser, urine and dung

(Ministry for Primary Industries, 21 June 2019)

Scientist use ancient gas bubbles trapped in ice, which they have been able to use to observe the earth's atmosphere as far back as 800,000 years. Concentrations of CO₂ have naturally fluctuated from 170-300ppm. When CO₂ is high, earth has been in a "warm" period, and when they are low, the planet has been in an "ice age". Since the industrial revolution, concentrations of CO₂ have increased at an unprecedented rate, especially in the last 60 years. (Scott, M, 2018).

Figure 2: History of C02 in the earth's atmosphere. Source DairyNZ

Ice Core Data – CO₂



In 2017, globally, the average concentration of carbon dioxide (CO₂) in the atmosphere was 405 parts per million (ppm) the highest it has been in recorded history, about 46% higher than the pre-industrial level of 280 ppm (Environment Aotearoa, 2019).

Comparing the other major greenhouse gases (Nitrous Oxide and Methane), refer Figure 3, each of the gases follows the same trend as CO₂ across history in different concentrations. All spiking since the industrial revolution. Looking at Methane (CH₄) the spike is over 270% higher than what has been previously observed. As these gases have gone through peaks and troughs, so have the global temperatures as mentioned and shown in Figure 2 and have followed a similar trend to the levels of greenhouse gases in the atmosphere (Scott, M, 2018).

Figure 3: Levels of greenhouse gases in the earth's atmosphere over the past 800,000 years. Source DairyNZ



The time is past when humankind thought it could selfishly draw on exhaustible resources. We know now the world is not a commodity. We have a single mission: to protect and hand on the planet to the next generation. (Hollande, F. 2016)

On the 4th October 2016, New Zealand ratified its commitment to the Paris Agreement which has the goal of limiting the increase of global average temperatures to well below 2°C pre-industrial levels and pursue efforts to limit the increase to 1.5°C above pre-industrial levels. To date, global temperatures have already risen by around 1°C.

New Zealand's emissions of greenhouse gases compared to other countries is small at less than 0.2%. However, all low emitting countries combined make up a total of 24% meaning changes we make can produce a considerable impact. New Zealand also has

a unique greenhouse gas profile and a profile that is unusual for a developed country for these reasons:

- Our country has one of the highest rates of emissions per person. In 2015, New Zealand emitted 17.5 tonnes of carbon dioxide equivalent greenhouse gases per person, 33% higher than the Annex I industrialised countries (United Nations, 2019) average of 13.2 tonnes, and higher than all but five of the 43 Annex I Countries.
- In most developed countries, greenhouse gas emissions are dominated by fossil fuels, especially burning coal for electricity and petrol for transport. New Zealand's produces 85% of our electricity from renewable sources meaning Agriculture dominates our emissions.

Agriculture and Climate Change

Agriculture produces nearly half of New Zealand's total greenhouse gas emissions with one-quarter of our total greenhouse gases coming from biological dairy emissions².



Figure 4: NZs emissions by sector. Source Ministry for the Environment

Note: Net emissions from the LULUCF sector are expressed as a negative number because the sector removes more greenhouse gases from the atmosphere than it emits.

² Emissions from livestock

85% of the dairy sectors emissions are also made up on the farm, with the other 15% coming from agriculture transport and processing. When breaking emissions down by Primary sector in 2017, around 78% of emissions come from Livestock, 21% from soils (fertiliser applications etc.) and the remaining 1% from urea and liming. (Emissions Tracker, 2019).

Dairy Emissions

It is significant to note and understand the emissions important to agriculture and why. Out of the three greenhouse gases causing climate change, two, in particular, are mainly emitted in the dairy industry.

Methane (CH₄); as mentioned earlier is produced by ruminant animals, by the methanogen microbes that are naturally present in the rumen. Most methane is emitted when a cow burps. (DairyNZ, Climate Change, 2018)



Methane is particularly essential to understand as a greenhouse gas as out of the three gases that contribute to climate change CH₄ has a shorter life span in the atmosphere, roughly 12 years, and is 25 times more potent at warming than CO₂ (DairyNZ, Climate Change. 2018). Although it is a potent greenhouse gas, the warming of this gas is significant over the first decade and then gradually decreases again with most of the effects gone within a century, compared to Nitrous Oxide (N₂O) which has a warming potential of 120 years and Carbon Dioxide (CO₂) which warming continues for hundreds of thousands of years.

Nitrous oxide (N₂O): Nitrous oxide gas commonly comes from the conversions in the soil by microbes of nitrogen in fertiliser, urine and dung. Nitrogen fertiliser is used to increase plant production in both dairy and crop farming. The amount of nitrogen fertiliser used in New Zealand has increased substantially over the past 30 years, mainly as a result of the increase in dairy production (Ministry for Primary Industries, 21 June 2019)

Figure 6: How Nitrous Oxide is produced. Source DairyNZ



HOW NITROUS OXIDE (N₂O) IS PRODUCED

Nitrous Oxide is 298 times more effective than CO₂ at trapping heat and has an average atmospheric lifetime of 114-120 years. (Stats NZ, 19 October 2017)

80% of on farm agricultural greenhouse gas emissions come from methane with the other 20% of on farm emissions coming from Nitrous Oxide. To put in into perspective from a

glass of milk, 90% of the emissions come from on farm, 9% is from manufacturing, and 1% of the footprint is from international distribution (Philips, L. 2019)

Horticulture Emissions

Throughout my research process, I have found it challenging to understand the total emissions that come from the Horticulture³ sector as well as potential sequestration. The reason for this is the emissions from Horticulture and cropping contribute less than 3% of New Zealand's total biological emissions, which come from Nitrous Oxide as most emissions come from fertiliser use. (On-Farm Options to reduce agricultural GHG emissions in New Zealand, 2017). Along with a low contribution to biological emissions, the sector has a higher contribution of emissions in energy due to production houses, transport and storage.

New Zealand GHG Emissions

With the difference between New Zealand and the rest of the developed world, we could assume that no other country will look to combat methane or nitrous oxide, giving New



Figure 7: Comparison of NZ greenhouse gases Globally. Source Fonterra

Zealand a chance to show our ingenuity and become world-leading at reducing these gases.

This image from Fonterra highlights the difference in New Zealand's emissions verse the rest of the world. Showing the vast difference in methane emissions, the slight difference in Nitrous Oxide and also the impact methane has compared to the other gases.

Although agriculture at this time is a high emitter for greenhouse gases than other industries in New Zealand, it is essential to note that work that dairy farmers have done

³ Horticulture in this report includes Fruits, Berries, Vegetables, Vineyards

over the years to keep emissions down and improve where they can. Since 1990 agricultural emissions have increased by 15%, however, they would have increased by 40% or more without the work that has been done today in the way of understanding use of fertilisers, reducing stocking rates, planting trees, fencing waterways and becoming more efficient on the farm.

Consequences of Climate Change for New Zealand

The effects of climate change in the future all depend on the total greenhouse gases that are emitted into our atmosphere. Projections are that with no additional efforts to reduce greenhouse gas emissions, the earth's surface temperature will increase by 3.7°C-4.8°C by the year 2100, relative to average temperatures from 1850 to 1900. By reducing greenhouse gas emissions by 40-70% by 2050, scientist predicts the average warming is likely to stay below 2°C.

Today we have already started to see the effects of climate change and the impact it is having on our environment and farm businesses. Currently, some of what New Zealand is experiencing is listed below (Environment Aotearoa, 2019):

- Increased temperatures New Zealand's annual average temperature has increased by 1-degree Celsius since 1909.
- Soil Moistures have become drier.
- Glacier ice has reduced by 25%. 15.5 cubic kilometres of ice sheet lost, enough to fill Wellington Harbour.
- Sea Level has risen between 14-22cm since 1916, places such as Nelson are experiencing flooding during high tides.
- Ocean acidity has increased since 1998, which affects the growth of shellfish in our waters.
- Mismatches in timing between some species and their food sources.

Figure 8: Current consequences of climate change on our environment. Source Environment Aotearoa



CHANGES ARE ALREADY AFFECTING NEW ZEALAND

- New types of pest and diseases affecting agricultural production, biodiversity and coastal erosion.
- It will affect what and how much New Zealand can grow or harvest both on the land and in the sea.

The Ministry for Environment (22 March 2019) has made some projections around the possible changes in average temperatures and rainfall by region.

Figure 9: Predictions for future rainfall and temperatures in NZ. Sourced Ministry for Environment

Annual average temperature changes by 2090

Under a low emissions scenario (left) and a high emissions scenario (right) compared to the 1995 baseline



Annual average rainfall changes by 2090

Under a low emissions scenario (left) and a high emissions scenario (right) compared to the 1995 baseline



The increased rainfall and temperatures put risk and pressure on our ecosystem and then, in turn, our risks and opportunities around farming. It will change the way we farm through soil changes (being wetter or drier), when and what crops we plant for feed, the risk of extreme drought or floods, and also the potential risk of increased or change in pest type.

There has been vast research on the likely impacts of climate change in the future. All of these changes will impact our environment, our lifestyle, businesses and the economy. These impacts and changes in climate impact not only the Dairy Industry but all sectors and put pressure on the food production industry as a whole.

Net Zero in New Zealand (Vivid Economics, 2017) was commissioned to apply scenario analysis across the New Zealand economy (in both land and energy) to help find long term low emissions pathways in line with the Paris Agreement.

The report talks about the requirements to decrease greenhouse gas emissions not only due to our commitment to the Paris Agreement but also the need to reduce emissions from an economic standpoint.

Citing the Stern review, the study highlights that the benefits of early and robust action on climate change outweigh the costs of not acting at all (Stern, 2007). Along with further studies which also reinforce Sterns conclusion that *the economic costs of climate change might be even greater than originally considered when the account is taken of the impact that climate change may have on productivity and hence long-run growth (Dietz & Stern, 2015).*

Land Use Change as a Mitigation Option

Land use change is currently one of the most effective ways to reduce greenhouse gas emissions in agriculture⁴. The main form of land use change that is generally discussed as an option for dairy farmers is forestry. There have been several studies around land use change on dairy farms to look at what overall emissions would do and what it would also do to the profitability of the farm business. While forestry can offer benefits of carbon sequestration and high reduction in emissions, the low profitability means it may not be a realistic option for some dairy farmers to reduce on-farm greenhouse gases. In contrast, Horticulture can offer higher profitability with low greenhouse gas emissions per hectare, which could assist dairy farmers in retaining overall profitability (Resigner, Clark, Journeaux, Clark, Lambert, July 2017). Some farmers may be able to achieve reductions with no significant impact to their business for others; the overall effect could be substantial. With dairy being our highest export earner if reducing emissions on farms

⁴ Other effective mitigation options include: reduce stocking rate, once a day milking, breeding low emitting animals, change in feed intake,

came at a negative cost to farmers, the position of New Zealand's most successful export industry may be threatened (Vivid Economics, 2017).

Could a land use change into horticulture be a positive change for dairy farmers to not only assist in reducing on-farm emissions but also to assist with farm profitability or risk?

There have been a few studies completed that suggest horticulture could, although not an overall solution, be an answer to assist in reducing emissions effectively and efficiently.

One study prepared for Motu Economic and Public Policy Research found that to reach our emissions targets for 2050 seemed possible with no additional on-farm mitigation through new technology however if achieved without a shift towards horticulture, mitigation technology or permanent forestry then reductions would be difficult to sustain in the future as forestry expansion is limited. With development into horticulture, by one million hectares, this led to an emissions reduction almost identical to reductions achieved from new technologies. If we can achieve a combination of horticulture increase and new technologies emissions will be more manageable to sustain in the future. (Dorner, Djanibekov, Soliman, Stroombergen, Kerr, Fleming, Cortes-Acosta, Greenhalgh. 2018)

Comparing average dairy emissions to average horticulture emissions, the difference in overall on-farm emissions is significant. Referring to Figure 10 and 11 below, figure 10 shows the average tonne of greenhouse gas emissions from dairy is 9.6 with conflicting numbers of 12 tonnes per hectare in other studies (Resigner, Clark, Journeaux, Clark, Lambert, July 2017), taking note that the majority of emissions from a dairy system are biological emissions. Whereas in Figure 11 the average total of emissions from a horticulture crop is between 2.4-5.5 tonne with the majority of emissions down to 0.17-1.03 tonne per hectare.

Figure 10: Average emissions per ha for a dairy system. Source: Mitigation and cost of on-farm greenhouse gas emissions. Table 1

TABLE 1: Average Biological GHG emissions per hectare (CO ₂ e)			
		Average Tonnes GHG/ha	Range tonnes GHG/ha
	Dairy	9.6	3.1 - 18.8

Figure 11: Emissions per ha for main horticultural and arable systems. Source: On-Farm options to reduce agricultural emissions in New Zealand Table 16

Crop System	Average Total Greenhouse Gas Emissions (TGE) T CO ₂₋₄ ha ⁻¹	IPCC Biological Greenhouse Gas Emissions (BGE) T CO ₂₊ ha ⁻¹	Average Percentage of TGE as BGE %
Kiwifruit	5.5	1.03	19
Wine grapes	3.0	0.17	6
Apples	5.0	0.71	14
Arable !	2.4	0.95	40

A study around permanent horticulture was presented as an option for low emitting land use. Modelling work was done on a pip-tree crop, where an area of a farm was taken out to grow chestnuts gave the below results.

Figure 12: Impact of a permanent horticultural crop on a dairy farm. Source AgFirst

	Change in GHG	Change in EBIT
Dairy Farm		
+ 10 ha chestnuts	-5%	96%
+ 40 ha chestnuts	-24%	346%

With changing the land use on a dairy farm to permanent horticulture, the study showed there is a decrease in greenhouse gas emissions as well as a positive impact on the farm's EBIT. While this could be an

option for future mitigation, soil types, crops and regional climates need to be taken into consideration. (AgFirst, 2019).

Horticulture is currently planted on 190,000 hectares in New Zealand and according to statistics established horticulture operations have higher profitability per hectare than dairy operations ranging from \$5,000 to \$20,000 and above. (Resigner, Clark, Journeaux, Clark, Lambert, July 2017). Dairy operations have profitability of around \$1,599 per

hectare (Dorner, Djanibekov, Soliman, Stroombergen, Kerr, Fleming, Cortes-Acosta, Greenhalgh. 2018). If the reduction in greenhouse gases is significant and the return per hectare is also significant then why are we not seeing a large portion of horticulture business buying dairy farms to convert or dairy farmers turning some land into horticulture?

Although there are a lot of positives to a land use change into horticulture barriers such as time, knowledge, infrastructure and cost could all be reasons as to why current land use changes are not taking place. The challenges are that there is not one hard or fast rule for across the board farming and when considering land use change there are a lot of variables to consider such as soil type, location, climate, and set up of infrastructure. Generally, the wait for return could be up to five years, which also may not be sustainable for a farm business to wait for.

Opportunities for a changing climate

"There are risks and costs to action. But they are far less than the long-range risks of comfortable inaction." (Kennedy. John, F)

Climate change poses a lot of risk to the food production industry. For Dairy farmers, there is a concern for drought, floods, the ability to care for our livestock during intense weather patterns such as storms, the threat of cyclones, or extreme heat. Our ability around pasture growth could be compromised, resulting in a loss of production. Due to the future risks posed to a business looking outside the square to see what

- 1. Might help reduce emissions on farm
- 2. Might help future proof a farm business as the climate changes seem logical.

Currently, dairy is farmed on 2.6 million hectares (ha), fruits and berries 120,000ha, vegetables 70,000ha and grains 449,000ha (Stats NZ, April 2018). According to the reports referenced in this paper, the available land to go into horticulture is anywhere between 1.5million and 3.2million hectares, taken from both dairy and sheep and beef. For dairy farmers to be able to diversify their current farming platform into horticulture

information is need to understand what could grow best on their platform. Currently, from what I could find, and well outside of the scope of this paper, there is no mapping around best soil types, climate and growing ability to help dairy farmers understand their potential. However, if this could be achieved, combined with the work done on how climate change will affect our landscape, I feel these tools would open up opportunities to help dairy farmers convert land use.

From a value-add point of view to the end product of what we are producing, Customers and consumers are more interested in climate change and sustainability than ever before. Taglines such as Sustainable, Organic, Environmentally Friendly, all gain consumer confidence and support. There is a lot of awareness of the impact on the climate and a focus for consumers on where their food comes from, how it's produced, and consuming food that is healthy for them and healthy for the world (Philips, L. 2019).

Although the option to diversify a farm business into other primary sectors is very dependent on soil type, farm business and location. The idea of bringing sectors together onto the same sustainable platform that tells a story of bettering the environment fits into what consumers are looking for and wanting out of their produce.

For example, looking into the future where we are able to work out what emissions come from a dairy farm, fully understand what emissions come from a crop or orchard and also what sequestration is achieved from this. Take a farm that has reduced its stocking rate, worked on pasture management and in turn reduced overall emissions from the dairy platform. With the farms reduced stocking rate, they have been able to plant an avocado orchard on the land that has been freed up and dramatically reduce further or even offset the emissions from farm activities completely.

"Carbon Neutral New Zealand Produce or Carbon Positive New Zealand Produce"

How great would that look branded on the side of a bottle of milk or a bag of avocados?

Figure 13: An example of branding could be used across sectors if we were able to collectively achieve carbon neutral or positive carbon agriculture in New Zealand. Carbon Positive and Carbon Neutral Labels created by Amber Carpenter. Milk bottle image sourced by Fonterra. Apple image sourced by Fresh fruits and vegetables NZ and Avocado image sources by NZ Avocado



Could we come together and market/brand New Zealand produce as carbon neutral or carbon positive food products?

Climate Change Survey

Reasons behind the Survey

As I went on the journey of understanding climate change in more detail and the effects that greenhouse gases had on our land and environment, I became interested to know what the farming communities' thoughts and understanding were on climate change. As someone that already has a passion for the environment, animal welfare and knowledge of climate change, I learnt a lot during this research paper when I thought I knew a fair bit to begin with.

I started to think if this is the case for me, someone already involved in climate change, what were the thoughts, understanding and education of others.

In terms of farm diversification, I wanted to know what farmers thought about this idea. Are farmers currently diversifying, what are the challenges, how did they feel about diversification and did they think it was feasible? Could understanding the farming communities' feelings and knowledge on climate change as well as looking at other mitigation options help us on the journey to reducing our emissions?

I conducted an online survey of 10 questions aimed at dairy farmers in the position of the farm owner, sharemilker or contract milker that would be impacted by the need to understand climate change and greenhouse gases as the industry starts to move to reduce our emissions. Over the six days, the survey was conducted, there were 100 responses. The survey was posted through social media channels such as Facebook and Twitter as well as through email correspondence. The survey was anonymous as I wanted the real, unjudged feelings of the respondents who knew their thoughts and opinions were safe in the knowledge they were not able to be contacted or mentioned once this report was published.

Results and Analysis

Please refer to Appendix One for full survey results.

In the first half of the survey, I wanted to gain the respondent's knowledge around the topic of climate change. As climate change is still a controversial topic with beliefs on either side of the fence, a large percentage of respondents, 84%, believe climate change is real and poses a threat to the future of the primary industries. When understanding the sector that emits the most greenhouse gases in NZ, 63% of respondents believed other areas such as Waste, Industrial processes and energy were the highest emitters with only 37% understanding that agriculture was the largest emitter for New Zealand.

When asked the question "Do you believe the NZ dairy industry should reduce its greenhouse gas emissions to help combat climate change?" an overwhelming 72% of respondents believed the dairy industry should reduce emissions even though a vast majority in question two⁵ were not aware the dairy industry are the highest emitters.

A question was included to see if dairy farmers were aware of how to obtain the total amount of greenhouse gases emitted from their farm business. In hindsight, this question

⁵ Appendix One Page 38

should have been asked differently. My aim for this question was to understand if farmers knew how to obtain the total amount of greenhouse gases that were currently being emitted from their farm business. After releasing the survey and seeing the results this question was worded incorrectly by me giving a mixed understanding of how to answer the question.

75% of responses showed they potentially did not know what their farm business was emitting with 58 of the 75 responding with a simple NO and the other 17 reading the question differently to how I intended it by answering Methane, Farm Equipment or science. The 25 responses that answered yes varied in where they obtained their information with 12 mentioning overseer, and the final 13 ranging from DairyNZ, Farm Consultant, Fonterra.

The second half of the survey was aimed at the feelings, willingness and current positions of diversifying a farming business.

When asked, "Are you doing anything in your farm business currently that is helping reduce emissions?" 56% of respondents are actively trying to reduce emissions in their farm business through varying different options such as planting trees, reducing nitrogen use, reducing stocking rate, solar power, reducing vehicle usage, and increasing soil biology. When it came to considering diversifying a farming business to include another sector or sectors such as beef, horticulture or arable to reduce emissions, overwhelmingly 70% of respondents answered yes. These respondents were open to ideas, keen to look into the viability and profitability of what diversification would do for their business and the environment. The majority of respondents already had an idea in mind of what they would diversify with. One respondent answered "Absolutely. Although dairy is our" specialty subject", adaption in a changing world is essential. Milking goats, horticulture, cropping, tourism? For those respondents that answered no their reasoning were around cost, labour availability, not owning a farm and also understanding/education around other sectors and how you would diversify.

Challenges to a farm business that would prevent diversification was an open question with eight options to choose from and the ability to select more than one option. The biggest challenge for farm businesses to look outside of their current structure is cost (70%) and infrastructure coming in second (51%). Time, Compliance and Capability all came in as the least challenging around 25-21%, showing that farmers would put the time in, work on compliance and make sure they were capable in another sector. "Other" challenges was an option, which came in at number four (31%) with respondents stating profit, clarity, aspiration, and passion as other reasons why diversification would be a challenge, one respondent's thoughts were "As a dairy farmer I'm sick of being blamed for everything, so I guess I'm feeling a bit 'anti' about being told to change what I'm doing because I'm the main cause of the planet being destroyed yet again"

Lastly, when asked to give a brief outline of thoughts on climate change and our responsibility as a sector to reduce emissions 93 out of the 100 respondents voiced their opinion. The opinions were heartfelt and with a genuine passion for the dairy industry and the future of our planet. The general belief was that climate change is happening and human-made influences are responsible. Although dairy farmers need to play their part in reducing emissions, the responsibility is not solely theirs, and all sectors and communities need to do their part. We are a progressive and innovated industry and have an excellent opportunity to lead New Zealand and the rest of the world on how to reduce emissions. Education is vital to making a change. However, we cannot expect farm businesses to make significant changes with unknown impacts; we need to be mindful and make smart changes with correct facts. Currently, the mitigation options aren't viable for most farm businesses, and there is limited knowledge around what we can do to reduce emissions effectively. Overall, we have a moral responsibility to do what we can to protect and look after our environment and planet for future generations.

Summary

Overall the survey highlighted that the majority of dairy farmers believe climate change is a real threat to the primary industries; however, more education is needed to understand why changes need to be made to help reduce emissions and how this can be achieved. Farm diversification is being thought about and approached by many, and it is down to mainly cost and infrastructure as to the challenges around diversification whereas time, compliance and capability is not as much of a problem. There is a strong sense of Kaitiakitanga among dairy farmers overall whether they believed in climate change or not and overall their passion for ensuring we are protecting our environment for future generations trumps all.

Recommendations

Further research:

What is the potential sequestration of horticulture, viticulture land use? If the estimated sequestration rates of a crop or orchard can be worked out, then that could help understand if those stores can offset the emissions on a dairy farm and/or the emissions the crop or orchard already emit.

Will increasing horticulture around New Zealand decrease emissions or could they potentially increase them? At the moment, the majority of emissions in horticulture come from energy or fossil fuels. If the industry was to expand what is the rise in emissions from this?

Land use Mapping, understanding soil types and climate of New Zealand land could help dairy farmers understand what is best suited to grow on their dairy platform if they were looking to diversify. Combining this land use map with the science around estimate changes to our environment might also help farmers understand future possibilities in terms of new crops, types of fruits/vegetables etc to grow.

Understanding what barriers farms are currently facing around diversification is needed.

Bring Sectors together:

If horticulture is a possibility of reducing emissions in a farm business, how can we bring sectors together to work towards this common goal? And by achieving this goal together, how we can brand this to the world around our environmental sustainability in our packaging and overall story?

There is a possibility to market New Zealand as carbon neutral or carbon positive if we can get sectors offsetting each other emissions and working together to reduce emissions overall.

Look outside the square of your business:

Farm diversification may not be for you. If it is something you have been thinking about, what is holding you back? Look at the possibilities on your current farm. Where is your farm situated? What is the possible climate change implications to your farm in the future? Could you be sitting on land that is perfect for Kiwifruit, apples, blueberries and could diversifying your farm business assist in the profitability of your overall business?

Ask Questions:

What is your farm business currently emitting, and how do you find this information out? Overseer, Farmax and other tools can help understand what emissions are coming from your farm business to understand better where change can be made.

Talk to other dairy farmers and other primary sectors in your region. The primary sectors need to come together to discuss and align on how we are going to tackle climate change for the future of New Zealand food production. The implications of climate change will affect all sectors. The sooner we are aligned for this common goal, the sooner we could start making an impact.

Support:

There is a desire in dairy farmers to look into diversification, what support around finance and education can be given to them to help them better understanding the possibilities, challenges and requirements to change their current business structure. New Zealand Dairy farmers are the best at what they do, support and the chance to be educated in other sectors would help in the possibilities of diversifying a dairy platform, not to mention great people that are passionate about the primary sectors and the environment would be growing our fruits and vegetables as well.

Conclusion

We are the first generation to be able to end poverty and the last generation that can take steps to avoid the worst impacts of climate change. Future generations will judge us harshly if we fail to uphold our moral and historical responsibilities. (Ban, K. 2016)

Climate change is a complex and continuously changing subject. The science and information around where climate change is today and how we are going to tackle this as a species is forever evolving as new information comes to light.

From the extensive research that has already taken place such as "Land use change as a mitigation option for climate change" - Motu, On-Farm Options to reduce agricultural GHG emissions in New Zealand" - NZ Agricultural GHG research centre and "Mitigation and cost of on-farm greenhouse gas emissions" – AgFirst there is a lot of evidence to suggest diversification into horticulture is not only beneficial to emissions but also potentially profitable. Although the research suggests these positive outcomes, it also notes that there is no one size fits all solution.

Every farm is different; every farmer is different. We range in farm size, herd size, systems, soil type, climate, profitability, infrastructure, and management.

If we can have a better understanding of what horticultural crop can be grown where, what will the emissions be from the growth of horticulture and what positive effects will come from diversifying into this sector the opportunity to future proof not only farm businesses in New Zealand from climate change but also the ability to market our collaboration and success of total carbon reduction to the world could increase the value of our products further to the world.

At the moment we do know, New Zealand dairy farmers are already doing more than their bit in the reduction of greenhouse gases and will still do more to protect the environment and our planet from further damage. There is an opportunity to come together as sectors, from the grassroots level to industry head, to achieve this common goal and work together and support each other in how we are going tackle this "Titanic" problem.

The responsibility of climate change and the urgent need to take action sits with everyone, every industry, every sector and every individual. The effects of climate change will impact us all. We are all Kaitiaki of New Zealand and owe it to future generations to guard and protect our environment and our country and hand it over to them in a better condition than it was handed to us.

References

AgFirst. (April 2019). Mitigation and cost of on-farm greenhouse gas emissions.

- Alsop, P., & Kupenga, T. (2016). In *Mauri Ora Wisdom from the Maori World* (p. 148). Nelson: Potton & Burton.
- Dairy NZ. (2018). *Greenhouse Gases*. Retrieved from Its ok to be smart: https://www.dairynz.co.nz/environment/climate-change/greenhouse-gases-globallyand-nationally/
- Dairy NZ. (2019). *Budget Case Study*. Retrieved from Dairy NZ Budgeting: https://www.dairynz.co.nz/business/budgeting/budget-case-studies/south-westwaikato-system-2-2019-20/
- DairyNZ Climate Change. (2018). *What Climate Change means for Farmers*. Retrieved from Dairy NZ : https://www.dairynz.co.nz/environment/climate-change/what-climatechange-means-for-farmers/
- Dam, R., & Siang, T. (2019, April). What is Design Thinking, and Why is it so popular. Retrieved from Interaction Design Foundation: https://www.interactiondesign.org/literature/article/what-is-design-thinking-and-why-is-it-so-popular
- Dietz & Stern, 2015. (2017). *Vivid Economics*. Retrieved from Net Zero in New Zealand: http://www.vivideconomics.com/wp-content/uploads/2017/05/Net-Zero-in-New-Zealand-Technical-Report-Vivid-Economics.pdf

- Dorner, Z., Djanibekov, U., Soliman, T., Stroombergen, A., Kerr, S., Fleming, D., . . . Greenhalgh,
 S. (December 2018). Land Use Change as a Mitigation Option for Climate Change. Motu
 Economic and Public Policy Research.
- Hollande, F. (2016). *Weforum*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2015/11/15-quotes-on-climate-change-by-worldleaders/
- Ki-moon, B. (2016). WeForum. Retrieved from Climate Change World Leaders: https://www.weforum.org/agenda/2015/11/15-quotes-on-climate-change-by-worldleaders/
- Manaaki Whenua. (2018). *Manaaki Whenua Home Page*. Retrieved from Manaaki Whenua: https://www.landcareresearch.co.nz/home
- Ministry for Primary Industries. (2019, June 21). *Agriculture and Greenhouse Gases*. Retrieved from Ministry for Primary Industries: https://www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/emissions-trading-scheme/agriculture-and-greenhouse-gases/
- Ministry for Primary Industries. (2019, June 17). *Climate change and the primary industries*. Retrieved from Ministry for Primary Industries: https://www.mpi.govt.nz/protectionand-response/environment-and-natural-resources/climate-change-and-the-primaryindustries/
- Ministry for the Environment & Stats NZ. (2017). *Our Atmosphere and Climate.* New Zealand: Ministry for the Environment & Stats NZ.
- Ministry for the Environment & Statz NZ. (2019). *Environment Aotearoa 2019.* Ministry for the Environment & Statz NZ.
- Ministry for the Environment. (2019). *Emissions Tracker*. Retrieved from Ministry for the Environment: https://emissionstracker.mfe.govt.nz/#NrAMBoDYBYF12ARnAlgHIFMAuL7AEzj6iIDseAH

KrrEA

- Ministry for the Environment. (2019, March 22). *Likely Climate Change Impacts in New Zealand*. Retrieved from Ministry for the Environment: https://www.mfe.govt.nz/climatechange/likely-impacts-of-climate-change/likely-climate-change-impacts-new-zealand
- Philips, L. (2019). *Cost of cutting the footprint*. Retrieved from nzfarmlife.co.nz: https://nzfarmlife.co.nz/cost-of-cutting-the-footprint/

- Reisinger, A., Clark, H., Journeaux, P., Clark, D., & Lambert, G. (July, 2017). On Farm options to reduce agricultural GHG emissions in New Zealand.
- Scott, M. (2018). *Climate Change Roadshow*. Retrieved from Dairy NZ: https://www.dairynz.co.nz/environment/climate-change/climate-change-roadshow/
- Stats NZ. (2017, October 19). *New Zealands Greenhouse Gas Emissions*. Retrieved from Stats NZ: http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Atmosphere-and-climate/nz-greenhouse-gas-emissions.aspx
- Stats NZ. (2018, April). Agriculture and Land Use. Retrieved from New Zealands Environmental Reporting Series: http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reportingseries/environmental-indicators/Home/Land/land-use.aspx
- Stern, 2007. (2017). Vivid Economics. Retrieved from Net Zeron in New Zealand: http://www.vivideconomics.com/wp-content/uploads/2017/05/Net-Zero-in-New-Zealand-Technical-Report-Vivid-Economics.pdf
- United Nations. (2019). *Parties Convention and Observer States*. Retrieved from United Nations Frame Work Convention on Climate Change: https://unfccc.int/process/parties-nonparty-stakeholders/parties-convention-and-observer-states
- Vivid Economics. (2017, March). *Net Zero in New Zealand*. Retrieved from Vivid Economics: http://www.vivideconomics.com/wp-content/uploads/2017/05/Net-Zero-in-New-Zealand-Technical-Report-Vivid-Economics.pdf
- World Economic Forum. (2019). *Quotes on Climate change by world leaders*. Retrieved from World Economic Forum: https://www.weforum.org/agenda/2015/11/15-quotes-on-climate-change-by-world-leaders/

Appendices

Appendix One: Climate Change Survey

Q1: Do you believe in climate change and the threat it poses to the future of the primary industries?

ANSWER CHOICES	 RESPONSES 	•
▼ Yes	84.00%	84
▼ No	16.00%	16
TOTAL		100

Q2: Which sector in NZ do you believe emits the most greenhouse gases?

ANSWER CHOICES	•	RESPONSES	•	
▼ Agriculture		37.00%	37	
▼ Energy		11.00%	11	
▼ Industrial Processes and Product Use		42.00%	42	
▼ Waste		8.00%	8	
▼ Land Use Change and Forestry		2.00%	2	
TOTAL			100	

Q3: Do you believe the NZ Dairy Industry should reduce its greenhouse gas emissions to help combat global climate change?

ANSWER CHOICES	RESPONSES	•
▼ Yes	72.00%	72
▼ No	28.00%	28
TOTAL		100

Q4: Do you know what greenhouse gas emissions are currently emitted from your farm business? If YES please also explain how you obtain this information.

Refer to Climate Change Survey, Results and Analysis (Pg.28-29) in this report for answers.

Q5: Are you aware of the current mitigation options available to reduce greenhouse gas emissions? If YES please state what these are and your thoughts around them.

41 responded No. The remaining responses varied from planting trees, once a day milking, reducing Nitrogen, reducing stocking rate,

Q6: Are you doing anything in your farm business currently that is helping reduce emissions? If YES what are you currently doing?

Refer to Climate Change Survey, Results and Analysis (Pg.29) in this report for answers.

Q7: Would you consider diversifying your farming business to include another sector or sectors such as beef, horticulture or arable to reduce emissions? If YES please explain what you would consider diversifying into and why, if NO what are the reasons.

Refer to Climate Change Survey, Results and Analysis (Pg.29) in this report for answers.

Q8: What are the challenges to your farm business that would stop you from diversifying into other sectors to reduce emissions? Please select all that apply.

AN	ISWER CHOICES	•	RESPONSES	•
•	Time		25.00%	25
•	Cost		70.00%	70
•	Infrastructure		51.00%	51
•	Knowledge		37.00%	37
•	Capability		21.00%	21
•	Compliance		21.00%	21
•	All of the above		29.00%	29
•	Other (please specify)	Responses	31.00%	31
То	tal Respondents: 100			

Q9: How important is climate change to you and your farm business at the moment?

ANSWER CHOICES	RESPONSES	-
✓ A great deal	15.00%	15
✓ A lot	15.00%	15
✓ A moderate amount	40.00%	40
▼ A little	24.00%	24
✓ None at all	6.00%	6
TOTAL		100

Q10: Please give a brief outline of your thoughts on climate change and our responsibility as a sector to reduce emissions.

Refer to Climate Change Survey, Results and Analysis (Pg.30) in this report for answers.