KELLOGG RURAL LEADERSHIP
PROJECT REPORT

Climate Change & Agriculture

East Coast of New Zealand

Photo Credit Jori Tuinier. PANUI Dairy Farm

JORI TUINIER ©

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Executive Summary

Climate Change and Agriculture

This research report has been completed as part of the programme requirements of the Kellogg Rural Leadership programme 2018. The report is about climate change and its effects on the dairy industry on the East Coast of New Zealand. I have been working in the industry for the past 12 years and have seen some of the changes in climate. As a farmer, you would be foolish not to have a better understanding about climate change and its effect on your business.

The scope of the research considers climate change impacts over the past 20 years, and into the next 20 years. The three key areas of enquiry are related to farming operations, productivity and environmental factors (rain, temperature and land erosion).

The key objectives are to**:**

1. Understand how climate change has impacted on operations and productivity in dairy farming/farming over the past 20 years.
2. Explore how climate change may impact operations and productivity in the next 20 years.
3. Consider the key environmental factors of rain, temperature and land loss on the future of dairy farming.

The literature review looks at climate change and the implications for farming operations and productivity. All information was gathered through an internet search under the topic climate change and agriculture. The main sources used were New Zealand government agencies, research centres and research from Universities.

The research methodology used anonymous questionnaires to gather data. The questionnaire was distributed via social media and email. I received 14 responses. The data from the research questionnaires was analysed by question and themed by topic. Six of 14 respondents say that climate change is a natural cycle of weather. Five of 14 say that climate change means less certainty and that farming operations will need to change. Six of 14 say

that the main risks are weather related, mainly drought, flooding and major weather events. Half of the respondents said climate change has not affected them. Nearly all respondents (10) have plans to mitigate the effects of climate change. Half of respondents say that compliance and cost does affect their farming operations and they expect these to increase.

For farmers, it is business as usual and for farming operations we manage for the extremes now anyway. However, the industry needs to develop sustainable practices, we need innovation, and government and regulatory bodies need to be reasonable about the cost of compliance.

Acknowledgements

Na Jori Tuinier tenei ripoata i tuhi, he kai pamu ia i Te Matau a Maui-a-Tikitiki-a-Taranga, i Te Mahia-mai-Tawhiti, a, he korero tautoko, he korero taunaki na etahi tangata, na etahi kaporeihana whanui ano hoki. E tika ana kia mihi au ki nga tangata katoa na ratou ano ahau i awhina ki te oti pai ai tenei tuhingaroa. Ana, me hangai tuatuhi ki a Patrick Ardwell, ki a Anne Hindson hoki, na raua ano ahau i poipoi, i akiaki ki te eke ki nga taumata o tenei mahi. A, he mihi ano hoki ki a Ngaire, nana ano au i arahi, i tautoko kia oti pai ai aku mahi. I te mutunga ake, me mihi kau ake ka tika ki taku whaiaipo ki a koe Crystall, ahakoa te whakahoha, ahakoa nga ra ka whakararu au i a koe, ka mea tonu nei koe e whai kia tere mai te oti nei i taku nei mahi.

This report was prepared by Jori Tuinier, Hawke's Bay dairy farmer, with comments and contributions provided by a wider range of other organisations and individuals. I would like to acknowledge all who have assisted me in completing this report. In particular I would like to thank Patrick Ardwell, Anne Hindson, and also my wife for giving me administrative support and putting up with me through this journey. Also, thanks to Ngaire Aben for structure, referencing and secretarial support.

Jori Tuinier

Introduction

Throughout earth's history, climate has fluctuated between periods of relative warmth and relative cold. Increasing concentrations of carbon dioxide and other greenhouse gases have taken a toll on the atmosphere trapping heat. And the climate has begun to respond. As a result, some things are certain. The sea will rise resulting in flooding, shorelines will recede so if you are not coastal now you will be, winds will change, and rain will fall. The earth's climate has had enough!

This report is about climate change and its effects on the dairy industry on the East Coast of New Zealand. I have been working in the industry for the past 12 years, and have seen some of the changes in climate, for example droughts, flooding, higher temperatures and erosion. As a farmer, you would be foolish not to have a better understanding about climate change and its effect on your business. If you don't understand it, you can't mitigate against it. Where there is change, there is cost. Where there is cost, there is compliance.

Prior to this project, my understanding of the effects of climate change included regular flooding and storms, higher temperatures, droughts and land erosion. Originally, I was interested in understanding how climate change would affect farming and the surrounding communities. Based on conversations with other people, from all walks of life, it raised the question of whether climate change was fact or fiction. Are we the cause – people, animals etc, or are we part of a cycle that has been reoccurring for centuries and should we be concerned? Although this was my initial query, for this report I have focused on the impact of climate change on agriculture.

If I were to repeat this research process, project and report, I would explore the science behind climate change. I would speak to the science experts. As advised, I would look at long-term trends of how climate change has/is impacting on agriculture and dairy farming. My current research is limited and has almost minimal science input. I also acknowledge that my sample base and number of participants is too small to reach real valid conclusions. However, as a first time process for me, and considering the pressure I put on myself, I am grateful to have had any questionnaire responses and to have been able to complete this report.

Aim

The aim of this project is to explore the implications of climate change in dairy farming/farming on the East Coast of New Zealand. The scope of my research will be climate change impacts from over the past 20 years, and into the next 20 years. The three key areas of enquiry are related to farming operations, productivity and environmental factors (rain, temperature and land erosion).

Objectives:

1. To understand how climate change has impacted on operations and productivity in dairy farming/farming over the past 20 years.
2. To explore how climate change may impact operations and productivity in the next 20 years.
3. To consider the key environmental factors of rain, temperature and land loss on the future of dairy farming.

Literature Review

This literature review will look at climate change and the implications for farming operations and productivity. The focus will be on the key environmental factors of rain, high temperatures and farm operations. All my information was gathered through an internet search under the topics climate change and agriculture. I did a wide search and chose 14 sources related to climate change and agriculture. I then chose eight sources that related to my key focus areas of rain, high temperatures and farm operations.

One of the main internet sources was New Zealand government agencies, for example Ministry for the Environment, Ministry for Primary Industries, National Institute of Water and Atmospheric Research and Ministry of Agriculture and Forestry. I also got information from research centres, for example ResearchGate, the New Zealand Agricultural Greenhouse Gas Research Centre and Royal Society of New Zealand. Lastly, I used research from Universities, for example University of Auckland, Massey University and University of Melbourne.

The government agency reports were commissioned pieces of research. Therefore, scholars and research centres conducted the research and completed the reports for government. As stated above New Zealand universities and one Australian university contributed to those reports. New Zealand research centres like National Institute of Water and Atmospheric Research, who are experts in their fields also contributed or produced the source material I have used in my literature review. Finally, Eckard (2008) of the University of Melbourne is an internationally refereed scholar, expert on climate change, well published and sort after international speaker on climate change (according to the University's website).

For this review, I will cover the literature by topic. The topics are rainfall and temperature, drought and impacts on farming and mitigations.

Rainfall and temperature

The first topic is rainfall and temperature. Those two things have the biggest impacts on agriculture. Ministry of Agriculture and Forestry (2010) (MAF) say that increased rainfall and different growing seasons will be a key effect of climate change. MAF (2010) also say that we will have, 'Drier winters and more frequent hot, dry, summer conditions' (p.1). Also, there will be increased rainfall which can lead to increased river flow and flooding in the lowlands.

The MAF 2010 article is about Canterbury, the issues of lower rainfall, increased evapotranspiration (this is when the sun sucks moisture from the soil), and increased frequency and severity of drought. Canterbury and the Hawke's Bay are similar with regards to being east coastal, flat topography and dry condition. The only difference is that Canterbury gets less rain.

However, the Ministry for the Environment (2001) (MFE) say that there are '… projected rainfall decreases for eastern areas of the Gisborne …, Hawke's Bay regions, in tandem with the expected increases in temperature' (p.6). I believe that will be a seasonal shift, we will get the same amount of rainfall but at different times of the year. The two agencies seem to be contradicting themselves. On the one hand they say there will be a decrease in rainfall, and then '… extremely heavy rainfall is expected to increase … in areas such as the summer dry hill country of coastal Hawke's Bay' (MFE, 2001, p.6). MFE and MAF both say there will be rainfall changes, increased river flows, and drier, wetter conditions.

In the article by the Ministry for the Environment (2018) (MFE), '*Climate change projections for the Gisborne and Hawke's Bay region*', they say '… the largest changes will be for particular seasons rather than annually' (p.2). In the Gisborne region, winter rainfall will decrease by 2 – 13%, spring rainfall will decrease by 3 – 15%. However, summer and autumn rainfall are expected to increase (MFE, 2018). MFE (2018) also say temperatures are on the increase for Gisborne and Hawke's Bay, 'Compared to 1995, temperatures are likely to be 0.7°C to 1.1°C warmer by 2040 and 0.7°C to 3.1°C warmer by 2090' (p.1). We are expected to have 8 to 51 extra days a year with temperatures over 25°C and less frosts (MFE, 2018), which I think will lead to more droughts. Majority of sources say that the temperature increase will extend our growing season and pasture growth, and allow us to diversify, for example in crops and grass species.

The Ministry of Agriculture and Forestry (2009) say that rainfall will become more unpredictable and storm ferocity will increase. 'Low-lying coastal land will be more prone to storm surges and flooding, (MAF, 2009, p.1). We are already seeing the effects of storm surges and flooding on the lowlands of the East Coast and the loss of infrastructure and lack of production.

Droughts

MFE (2018) say that effects of climate change will increase the number and duration of droughts. By 2090 the number of droughts will '… more than double compared to 1995' MFE, 2018 (p.3). This will result in water shortages, increased need for irrigation and fire hazards (MFE, 2018). MFE (2001) projected decreased rainfall for the East Coast. MFE 2001 says, 'If there is a greater frequency of drought years than this could have quite disastrous effects in this area.' (p.7). Farmers on the East Coast are still using some of the pasture species used when the MFE 2001 report was written, such as coxfoot. MFE (2001) say, 'Current pasture species aren't well suited to drought conditions' (p.9). Research and development needs to be done in the area.

Ministry for Agriculture and Forestry (2009) say there will be more droughts in the region and pressure on water sources. They also say westerly winds will intensify increasing fire risk in rural areas. Droughts will impact on profitability and require farmers to mitigate, for example stocking type and rate, change of pasture species, and water usage – whether it be bought or water consent.

Impacts – Positive and Negative

<u>Rainfall</u>

Ministry for the Environment (2001) (MFE) and Royal Society of New Zealand (2016) (Royal Society) both say rainfall will have a negative affect on lowlands but positive effect for the highland. However, for the highlands it could still be negative because they could get slips and erosion. Royal Society (2016) say that 'Decreasing annual average rainfall in eastern and northern regions of both main islands, plus higher temperatures, will increase the frequency and intensity of droughts and the risk of wildfires,' (p.2). MFE (2001) say '… very heavy rainfall could have major adverse effects on soil stability' (p.6).

Ministry for Primary Industries (2012) (MPI) say that variable rainfall will impact on seasonal timing of production. Seasonal shifts and pasture growth rates will impact on the planned start of calving and mating because this all depends on feed availability, if you don't get the rain, you don't get the feed (MPI 2012). The seasonal shift will also affect surpluses and deficts, for example in pasture protein. MPI (2012) explain the seasonal shift as being,

'Shorter spring seasons, but with higher potential growth. More variable autumns and earlier summer onset, with more water deficiencies' (p.19).

Disease and Parasites

Lake et al. (2017) say one of the impacts of climate change will be possible spread of pathogens between animals. Farmers may increase the shift of seasonal supplement causing more crowding than normal. Animals are not grazing or foraging, they are coming to the feed, and there is increased risk of pathogen spread. There is also increased risk of disease from pathogens and mycotoxins (including aflatoxins). Lake et al. (2017) explain, 'Harmful fungal metabolites under dry, hot conditions can also contaminate cereals and pulses during crop growth and post-harvest' (p. 21). For example, dairy farmers purchase cereals for in-shed feeding that could be contaminated and therefore contaminate milk products.

Parasites, particularly liver fluke, are a major parasite problem for East Coast farmers. Lake et al. (2017) say, 'Currently liver fluke infections commonly occur on the east and west coasts of the North Island and west coast of the South Island' (p.21). Liver fluke affects milk production. To illustrate, cows infected with liver fluke, will show a reduction in milk production by 300 litres (Virbac New Zealand, 2018). This will result in loss of profit by $176.08 per cow, annual lactation. Based on Fonterra forecast Farmgate milk price as at 31 August 2018 (Fonterra 2018), the calculation is: 300 litres of milk ÷ 11.5 milk litres = 26 milk solids x $6.75 = $176.08 per cow.

Other disease issues include stock facial eczema, exotic disease introduction, reduced immune systems, reduced fertility and increased lameness, and increased heat stress (Lake et al, 2017, p.21 – 23).

Productivity

MFE (2018) and MAF (2010) both highlight issues about the need for water. MAF (2010) say, 'the greatest losses are likely to arise from the effects of likely increased demand for water and increases in drought frequency and severity' (p.1). Pasture species and predominance will also be affected. MFE (2001) say, 'The potential spread of lower feed-quality subtropical grasses into pasture is a concern' (p.9). Increased temperature is going to lead to the predominance of kikuyu (subtropical grass) in the North Island east coast.

Climate change will impact on productivity and profitability. Loss of production is loss of profit. MPI (2012) say, '… infrastructural changes can be made to the milking platform and farm landscape to reduce heat and cold stress. Permanent change to the pasture species base is also an option, as are irrigation, sustained pasture renewal and the use of new forage crops.' (p.23). Mitigating the effects of climate change will come at a financial cost.

Mitigations

Considering all the impacts above, we would expect that the mitigations would be just as much. Mitigations are required for strategic adaptation, tactical adaptation, infrastructure and farm operations, production and management, bio-security, pasture species, and stock welfare. Time for change!

MPI (2012) say 'The range of current New Zealand dairy farming systems vary in their exposure to the effects of climate change – direct and indirect' (p.22). Eckard (2008) also promotes adaptation in the dairy industry. MPI (2012) advise the industry to make advances in pasture technology and plant morphology (rooting systems and water shortages), stocking rates, and animal science (genetic modification) to breed cattle that are heat and cold tolerant. The industry needs to consider new pest and disease management approaches (MFE 2018). To conclude, Eckard (2008) explains, 'While there is no doubt that climate change will bring some changes and challenges, it will also bring many opportunities for those willing to adapt' (p.4).

Methodology

The methodology uses anonymous questionnaires. Initially, the questionnaire was distributed electronically via social media on Facebook Survey Monkey, using the New Zealand Dairy Farmers' page and received seven responses. Due to the limited responses, the questions were revised.

The revised questionnaire was then distributed via email to 16 participants for written response. To ensure a balance between the social media responses and email response, I followed up with participants to ensure I got at least seven responses.

Of those that received the questionnaire via email, eight participants were dairy farmers and eight sheep and beef farmers. Half of the participants are in the dairy sector. Sheep and beef farmers were included because of a lack of dairy farmers in the region. Participants aged between 30 to 75 years old. The participants are generational farmers, farm owners, and three are contract milkers. I was unable to do follow-up interviews due to the farming demands and time pressures on participants and myself.

Analysis and Discussion

The data from the research questionnaires has been analysed by question and themed by topic. Analysis of responses by question sort to identify the key issue or idea as firstly stated by participants, and then where participants agreed, their answers were aggregated. To ensure all participant responses were considered, I included all answers as a category in the graphs presented below.

Two research questionnaires were used to gather data. Questionnaire One (via Facebook Survey Monkey) had 10 questions. Questionnaire Two (via email) had 5 revised questions. Although I used two questionnaires, the data gathered allowed itself to be grouped to answer the key questions of this research. These questions have been summarised to give titles to the graphs below.

Graph 1. What is Climate Change?

Graph 2. Responding to Climate Change

Graph 3. Risk to Farming

Graph 4. Impacts to Date

Graph 5. Advice & Guidance

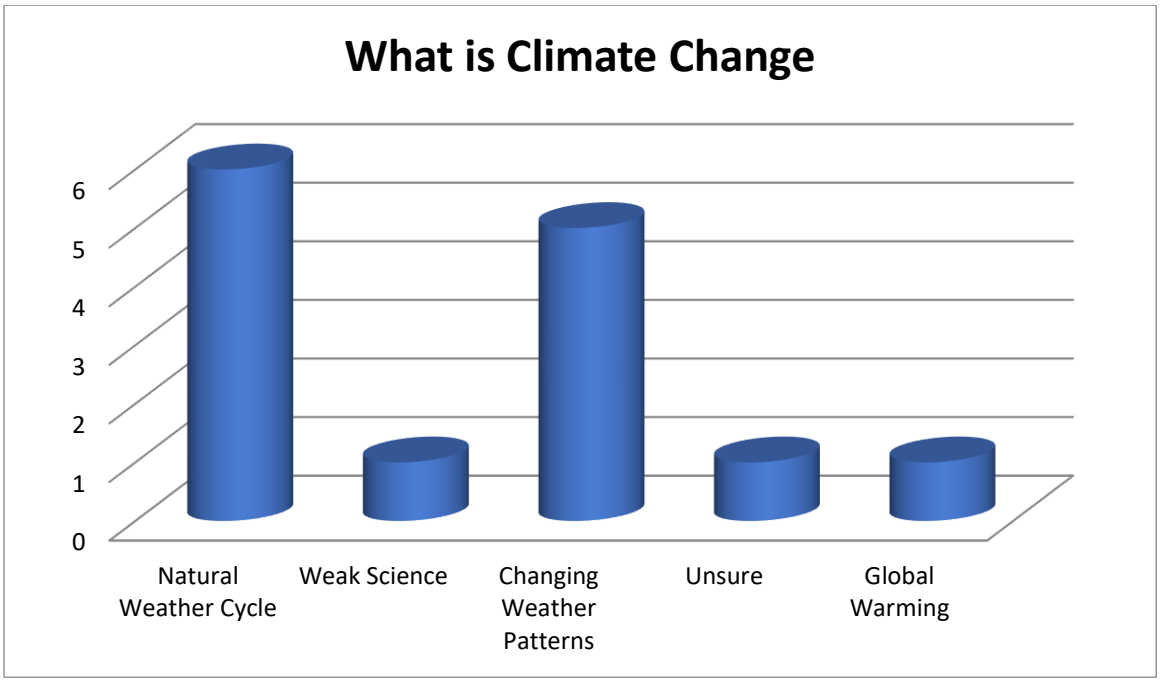
Graph 6. Future Impacts

Analysis of Responses

Graph 1. What is Climate Change?

The first question asks what respondents know about climate change. Six out of 14 respondents say that climate change is a natural cycle of weather, that has been happening for 1000s of years, and will keep occurring. The other respondents say that changes in weather patterns and extremes, and rising sea levels are effects of climate change. One respondent says climate change is only just beginning and the others say it is weak science. The respondent answers (excluding the last response regarding weak science) are consistent with the literature reviewed for this project (refer page 7.). The Ministry of Agriculture and Forestry (MAF) (2009 and 2010) and Ministry for the Environment (MFE) (2001 and 2018) both highlight changing weather patterns and impacts on rainfall and temperature as the biggest impacts of Climate Change.

Graph 1.

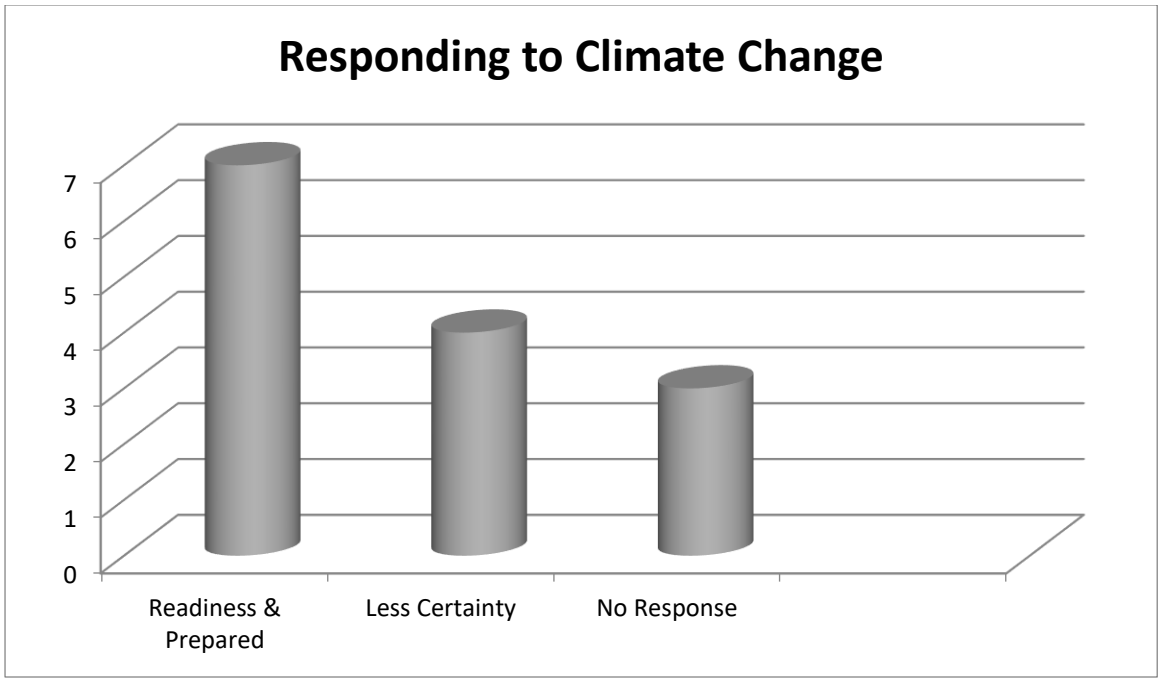


Graph 2. Responding to Climate Change

The next question asks what climate change means to them as farmers. Five out of 14 say that climate change means less certainty and that farming operations will need to change. MAF (2009) assert that climate change will lead to unpredictable weather, loss of infrastructure and reduced production. MFE (2001) say that research and development are required to mitigate the affects of climate change. So, there will need to be technological advances, farmers will need to farm to conditions (e.g. increased supplements) to manage seasonal extremes and be prepared for the unexpected. The other respondents say that increasing dry and extreme weather will affect them, they need to consider future generations and sustainability, and one respondent said that there would be massive disruption and impact.

Respondents were asked about their plans to help deal with the effects of climate change. Nearly all respondents (10) have plans to mitigate the effects of climate change. The responses are mainly about flexibility and managing risk. One said, 'I think productivity will plateau as the cost of production and compliance will increase'. Others said they would need to reduce stocking rate and consider seasonal shift. Only two respondents did not have a plan for the possible effects of climate change. Ministry for Primary Industries (2012) encourages the agriculture industry to adapt farming operations to mitigate potential risks to farming and productivity.

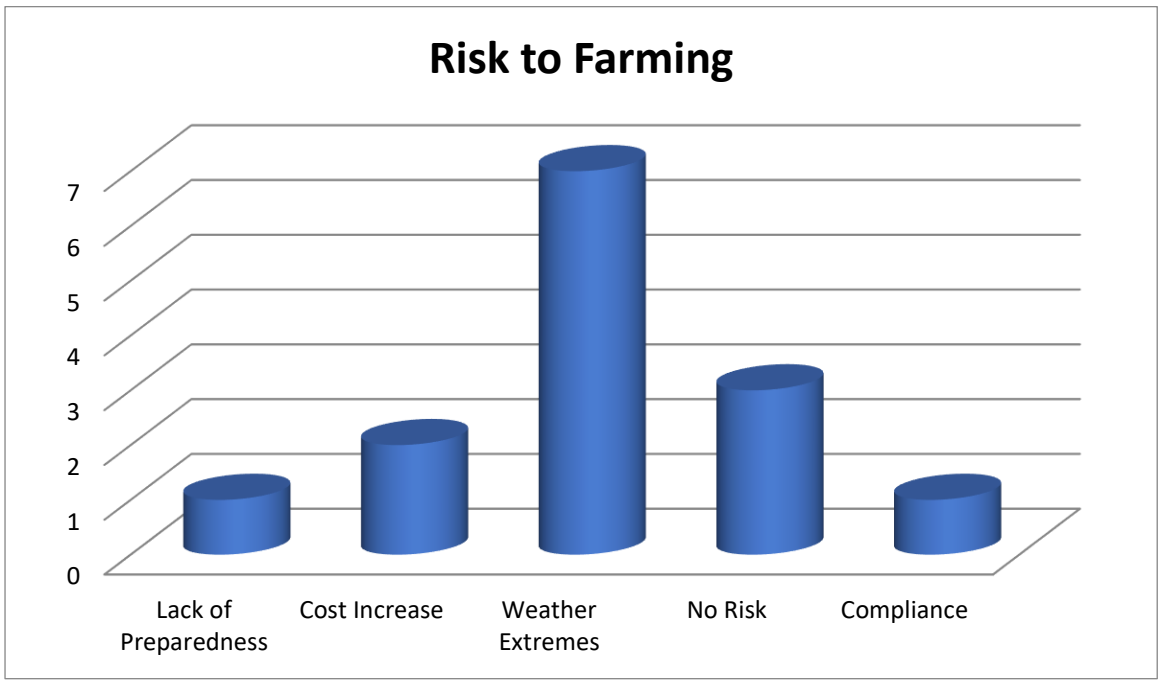
Graph 2.


Responding to Climate Change
7
6
5
4
3
2
1
0
Readiness & Prepared
Less Certainty
No Response

Graph 3. Risk to Farming

Respondents were then asked to think about the main risks to farming. Six of 14 say that the main risks are weather related, mainly drought, flooding and major weather events. They are worried that costs will rise for stock feed, water consent and regulatory costs (for example, emissions).

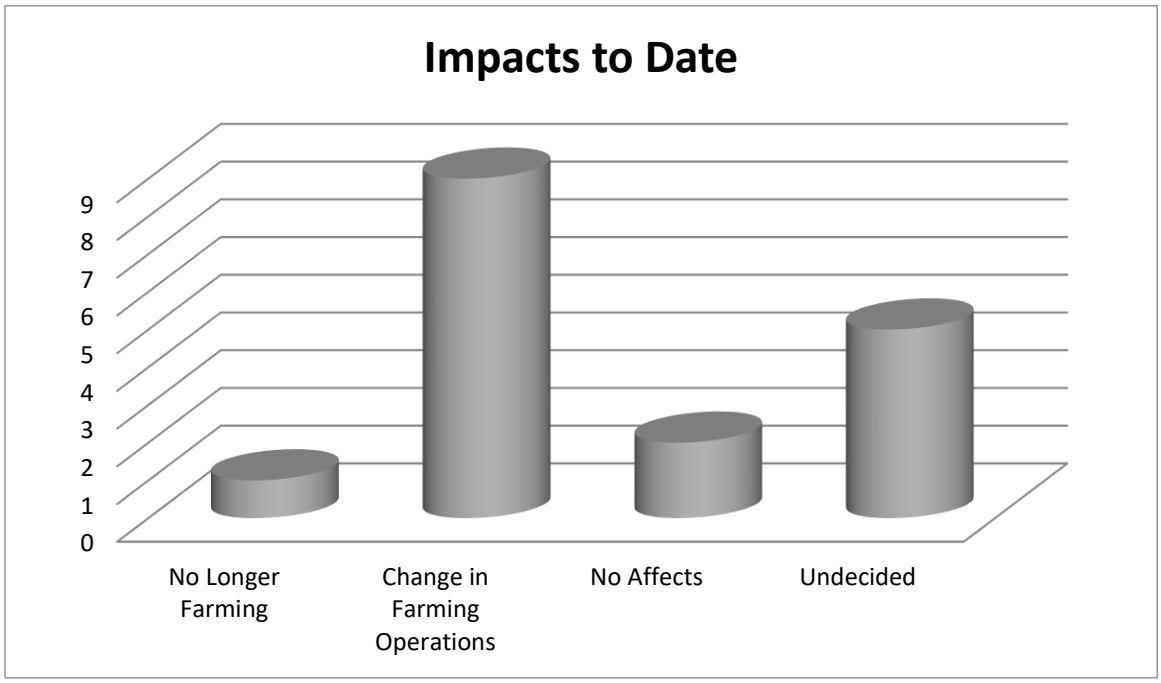
Graph 3.



Graph 4. Impacts to Date

When asked about how climate change has affected them, half of the respondents said climate change has not affected them. They say it is just business as usual, that 'the experts' say it is happening and 'justified or not and whether we can make a difference or not, will not really matter, we will be forced to change our systems'. This is consistent with the position present by the Ministry for Primary Industries (2012). MPI (2012) say the range of farming operations across New Zealand 'vary in their exposure to the effects of climate change – direct and indirect' (p.22). The other respondents say they are adjusting management techniques, planting riverbanks to mitigate for flooding and erosion, running a more fluid farming operation, responding to dry, wetter and more extreme weather, and less consistency with the seasons. Eckard (2008) tells the industry to make adaptations in farming practice to respond to climate change.

Graph 4.



Graph 5. Advice & Guidance

When asked about the tools or advice they were using for decision making about climate change, respondents said they were using external consultants, conducting their own research, using weather forecasts, and drones for imaging. Respondents are seeking external or expert advice, as the literature suggests they should. One recommended the use of industry professionals (DairyNZ) and another said to consult the 'Bible, Timothy 4 vs 3 about fake news and how bullshit is spread'.

Graph 5.

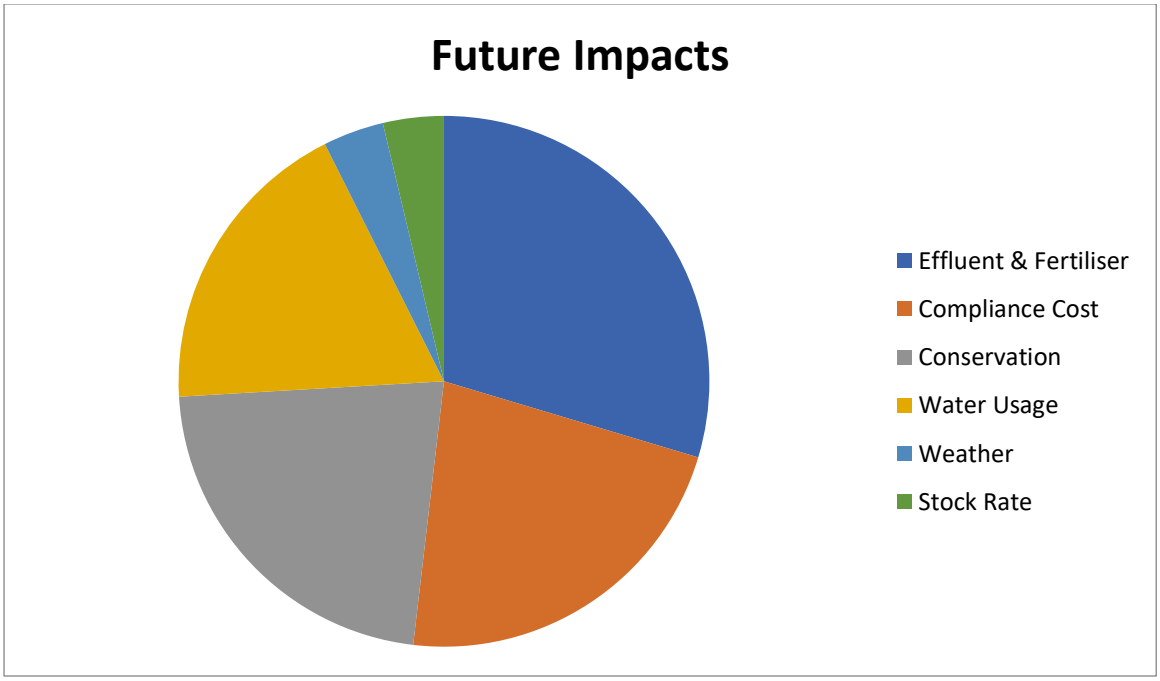
Graph 6. Future Impacts

The next questions asked respondents to consider the future impacts of climate change. Respondents said that they needed to stop the use of manmade fertilisers, use a more biological farming system, increase carbon in the soil, improve water catchment, develop better practices to keep waterways clean (leeching), and improve general education about the benefits of farming to the country.

Respondents were also asked about compliance measures affecting farm operations. Half of respondents say that compliance does affect their farming operations and they expect these to increase. Examples given included compliance costs for water take and effluent and nutrient management. They also say that compliance costs need to be reviewed for farming to be sustainable and that a reasonable partnership approach is a must. The affects of rainfall and temperature, increased number and durations of drought and pressure on water sources are projected affects of climate change (MAF 2009, 2010). These affects will have compliance costs.

Four responded that compliance does cost, it could have huge long-term costs, and that farming may be unviable and even 'costs could drive everyone off the land'. The others (3) said that at present there are no compliance measures affecting their farming operations.

Graph 6.



Further Comments

Finally, respondents were asked if there was anything they wanted to add, four responded as follows:

1. Am I concerned about the unfounded political doctrine around climate change with no unbiased evidence to back it up. Farmers need to lobby against changes made on doubtful science?
2. Do we think it is a concern?
3. The rural sector needs to educate the people that it is a natural thing (climate change).
4. Do you think we contribute to the speed of climate change?

Note: Had time allowed, I would have done follow-up interviews with some respondents to get further clarification on their answers, for example around sustainability.

Conclusion

When I started this project, I had the following objectives. I wanted to:

1. understand how climate change has impacted on operations and productivity in dairy farming/farming over the past 20 years.
2. explore how climate change may impact operations and productivity in the next 20 years, and
3. consider the key environmental factors of rain, temperature and land loss on the future of dairy farming.

As stated earlier, my understanding of the effects of climate change included regular flooding and storms, higher temperatures, droughts and land erosion. I wanted to understand how climate change would affect farming because I am in the industry.

For me, this research has confirmed what I thought. Most of the farmers that contributed to my research, agree that climate change is just a natural occurrence. For us, it is business as usual. So, for farming operations, we just keep doing what we are doing because we manage for the extremes now anyway. From me experience in the dairy farming industry, Hawke's Bay has always been a drought zone for as long as I can remember. Waikato has only recently been experiencing drought, so its new for them. Northland is the same.

In my opinion, there is no climate change, it is just revenue gathering, that's all it is. If you don't comply, you get charged. Whether we like it or not, the government has a focus on climate change and we need to be responding. We need to develop sustainable practices, we need innovation across the board – stock, grasses, emissions, systems, and lastly, we need government and regulatory bodies to be reasonable about the cost of compliance.

Recommendations

1. Mitigations are required for strategic adaptation, tactical adaptation, infrastructure and farm operations, production and management, bio-security, pasture species, and stock welfare.
2. Research and development needs to be done into pasture species and technology.
3. The industry needs to make advances plant technology and morphology in response drought increases.
4. The industry needs to diversify range of crops and grass species.
5. Droughts will impact on profitability and require farmers to mitigate, for example stocking type and rate, change of pasture species, and water usage – whether it be bought or water consent.
6. Need to consider seasonal timing of production. Seasonal shifts and pasture growth rates will impact on the planned start of calving and mating because this all depends on feed availability.
7. Need to understand the impacts of crowding and increased risk of pathogen spread and disease.
8. Need to plan for likely increased demand for water and increases in drought frequency and severity.
9. The industry needs to make advances in animal science (genetic modification) to breed cattle that are heat and cold tolerant.
10. The cost of compliance needs to be reviewed, for example water consent and fertiliser applications.

APPENDIX 1

Questionnaire distributed via Facebook Survey Monkey

The following questions were included in the questionnaire via Facebook Survey Monkey. I introduced my research along the following lines.

Hi, Jori here. I am doing the Kellogg Rural Leadership project, I need some help. Can you fill this in.

1. How would you describe climate change?
2. What does climate change mean to you as a farmer?
3. What do you think the main risks from climate change are for your farm(s)?
4. How do you think climate change has affected you and your farm so far?
5. Do you have any plans in place to help you deal with the effects of climate change?
6. What are they?
7. What tools or advice are you using to help you make your decisions about the effects of climate change?
8. Please describe any climate change related compliance measures that are affecting your farming operation.
9. What are the impacts of these compliance measures on your farming operations? (eg costs, land use options, location of structures).
10. Is there anything you expected me to ask about the effects of climate change that I have not asked? If so, please explain or describe these.

Questionnaire distributed via Email Dairy Farming on the East Coast - Questionnaire

The aim of my project is to explore the implications of climate change in dairy farming/farming on the East Coast of New Zealand. The scope of my project will consider climate change impacts from over the past 20 years, and into the next 20 years.

The three key areas of enquiry are related to farming operations, productivity and environmental factors (rain, temperature and land erosion).

Questions – Please answer the questions using bullet points and give examples if you can.

Please write your answers under each question.

1. What do you know about climate change, and what does climate change mean to you?

2. Thinking about the past 20 years:

   has climate change impacted your farming operations, if so how? has climate change impacted on productivity, if so how?

3. As farmers, how have you responded to climate change as it affects your business?

4. Thinking about the next 20 years:

   how do you think climate change will impact on farming operations? how do you think it will impact on productivity?

5. What do you think are the key environmental factors for the future of dairy farming/farming.

APPENDIX 2

Research Results and Data

Participant Response to Questionnaire – Facebook Survey Monkey

Participant 1

1. Weak science.
2. Knowing there will be changes but it's a natural cycle and being ready for them.
3. Being ill prepared for weather events.
4. More severe wet periods/more severe drys. Less consistency with seasons.
5. Continue being flexible.
6. Ensure supplement feed is available at correct times of the season. Ensure infrastructure is sufficient e.g. irrigation, invest in better tech e.g. pivots. standoff/feedpads.
7. Have found most weather-related info to be inaccurate. Use industry professionals

   e.g. DairyNZ studies for advice on other matters.

10. Do we think it is a concern?

Participant 2

1. Changing weather patterns, more extremes etc, global warming, sea levels rising etc.
2. Less certainty need for increased supplements to help manage seasonal extremes/somewhat as an insurance policy. Increasing concern around heat stress etc.
3. Inability to cost effectively feed animals owing to extreme weather patterns almost consistently – ie extreme weather is no longer occasional. It's business as usual. Also, regulatory costs aimed at driving changes re. emissions etc.
4. As above – weather patterns more variable, more reliance on supplements etc.
5. Increased summer cropping. Growing more supplements on farm. Looking towards shelter options for summer as much as winter.
6. As above.
7. Own research.

8. From a purely compliance angle none yet but anticipate increased levies, taxes and costs etc. There are of course others more related to nutrient management but those aren't 'climate change'.

9. Increased costs, becoming less viable and wondering whether we continue farming.

10. Can't think of any this minute.

Participant 3

1. A natural cycle of weather.

2. Farm to the conditions and look for any technological advances to manage these changes.

3. Drought, heat, snow and long periods of wet.

4. It hasn't affected farms any more in recent times than recorded history. Although weather cycles do affect farm practice and performance; and good management will be a competitive advantage if extreme weather cycles are combatted to mitigate damage to a minimum.

5. We have plans in place to manage weather risk.

6. Supplement banks for winter and dry conditions. Management also manages via using fodder beet to counter snow (as opposed to kale) and irrigation with supplement to counter dry periods.

7. 10-day weather forecasts.

8. None at present.

9. N/A

10. Am I concerned about the unfounded political doctrine around climate change with no unbiased evidence to back it up? Farmers need to lobby against changes made on doubtful science.

Participant 4

1. Something natural that has gone on for 1000's of years.

2. We have to be prepared for the unexpected. If there was no climate change we could bank on what happened the last few years on the same day!!!!

3. Flooding from time to time. Hot summers before it starts cooling again.

4. Not too much different from other years as we always have to be prepared for something different.

5. Stay farming and expect something different on this day next year.
6. Just the normal challenges of life, tomorrow will be different from today.

7. Stop listening to the Green party and reread the Bible 2 Timothy 4 vs 3 that tells us about fake news and how bullshit is spread.
8. The Green and the Governments move to use nutrient management programmes to manage us. Overseer is based on assumptions that are generated from assumptions!!!!
9. Cost could drive everyone off the land.
10. Your questions are leading to assume the climate change is anthropogenic. The rural sector needs to educate the people that it is a natural thing.

Participant 5

1. A warming of the ocean and increased intense weather events due to co2 emissions.
2. Increasing dry and extreme weather.
3. Flooding, droughts.
4. No effects so far.
5. No.
6. NA
7. Long range forecast.
8. NA
9. NA
10. NA

Participant 6

1. Cyclic.
2. Sustainability.
3. Costs.
4. Management techniques.
5. Yes.

6. Summer safe and wintering options.
7. Drones for imaging.
8. Effluent infrastructure.
9. Huge costs for long term.
10. Do you think we contribute to the speed of climate change?

Participant 7

1. Here now and only just starting.
2. Massive disruption and impact.
3. Weather.
4. Weather changes, drier weather and wetter winters.
5. Supply feed options, lower stocking rates and an open approach to the season – looking ahead not fixed plans.
6. As above.
7. Using external consultants to bring different views.
8. Water take, effluent management and nitrogen.
9. They cost money.
10. No.

<u>Participant Responses to Questionnaire - Email</u>

Participant 1

1. Planet warming – melting ice shield at Poles, rising sea levels, erratic weather events.
2. Maybe more drier summers – had irrigation on. No effect on production, but on farmers without irrigation, supplement on hand crucial.
3. Make sure you are prepared for weather events, i.e. supplement spare, irrigation rights sorted.
4. Not farming any more.
5. Water usage and conservation, effluent distribution, weather conditions, stocking rates.

Participant 2

1. Have general knowledge. Change in weather patterns, hole in ozone layer.
2. Yes, river boundary affected by flooding which is occurring more often than it used to. This impacts on productivity by flats being flooded and covered in silt and needing to be regrassed. Seasonal divisions are not as regular or consistent as they used to be.
3. Planting riverbank to try and stop loss of land. Making more supplementary feed. Running a more fluid farming operation to be able to respond to unexpected weather events.
4. I think it will only become more apparent with longer harder dry season and wetter harsher storm events. It may not impact on productivity if the farmer has feed options etc in place however the cost of these options means it may impact on profitability.
5. I think the cost of compliance has to be reviewed. Farming is an easy target but the solution needs to be looked at from a holistic model. In most cases farmers are people of the land and they do care about the environment as it is a big part of their livelihood. Any potential solutions need to involve in a sustainable and reasonable partnership approach.

Participant 3

1. Climate change I believe is a natural process that is being made worse/speed up because of humans. It means as farmers we are going to be under the spotlight from the rest of the world, justified or not and whether we can make a difference or not. Will not really matter, we will be forced to change our systems.
2. No, I don't think it has affected our farming operations yet.
3. I haven't yet.
4. As a contract milker, we will always be looking at farms that have good irrigation water. I think productivity will plateau as the cost of production and compliance will increase.
5. Stopping the use of man made fertilisers, going to a more biological farming system to look after our soils more and increase carbon in the soil. More irrigation, more dams to lessen the impact of the dry spells. Catch more of the water that runs out to sea. Getting the townies on board to back New Zealand agriculture, get them to understand they are buggered without it.

Participant 4

1. Climate change has been occurring for millions of years and will keep on occurring. Probably it will be hotter and drier on the coast.
2. No impact on farming operations or productivity to date.
3. Because 'the experts' say it will be hotter and drier we have installed irrigation.
4. If it does get hotter and drier, we'd have to reduce our stocking rate/productivity.
5. Virtually no dairy farming on this coast, but water and pollution run-off will be the key environmental factors.

Participant 5

1. More unreliable weather events.
2. Droughts, floods, general increase in weather events.
3. Compliance.
4. We are always trying to understand the effects and implications and make changes accordingly. Seasonal shifts.
5. Leeching fertiliser, effluent into the ground.

Participant 6

1. That it is to do with weather changes, and potentially some changes are caused by humans e.g. CO2 emissions. Need to plant trees and do our bit to save the planet.
2. Increase in water use. Shelter for animals from heat stress. Modify operations to address issues.
3. Do it as business as usual.
4. That's what you do in business, constantly evaluating practice and modifying, improving.
5. Cost of compliance, revenue.

Participant 7

1. I don't believe in climate change. Weather patterns change over ten-year periods, not in any order.
2. No. Weather patterns match your risk management, decisions of your/my business.

3. Yes.

4. I have been farming for 50 years. Adverse dry weather and wet weather in my opinion have not had any major changes.

5. Being aware of water quality and fertiliser use.

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Note: I researched and analysed these texts for my literature review, however did not use as references throughout my report[1]. Please see footnote.

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[1] Definitions: A reference list is a list of all the sources you have referred to in the main part of your assignment and should be included at the end of your piece of work, immediately before your bibliography.

[2] Note: This is a book therefore the title is italicized.