Agriculture Sector Climate Change Scenarios

The Aotearoa Circle

Mihi

Tukua te wairua, māna e whakahaumanu, e whakaroa te rerehua o Aotearoa mō ngā uri whakaheke.

Hei arataki i ā mātou mahi me tā mātou whāinga matua kia hono ai te ira tangata ki te taiao.

Tōia mai rā te kaha me te ngākau pono kia hatutū tahi ai tātou ki ngā āwhā arahi kia ora aka te ao tukupū.

Kia poipoia mō āke tonu atu.

Whakamaua kia tina, Hui e! Tāiki e!

Greeting

Release the spirit, to restore Aotearoa's beauty for future generations.

To guide our work and purpose in connecting people with the environment.

Let us draw in strength and integrity to meet the headwinds of today and lead for a better planet.

Ensuring it is nurtured forever.

United we affirm!

Whakatauki

Toitū te ahu whenua Pūmau ai te kākano	Sustain the cultivation of the land Hold on to the seed
Toitū te ahu moana Pūmau I te hua	Sustain the cultivation of the oceans Hold on to the essence
Toitū te ahu ngākau Pūmau ai te aroha	Sustain human growth Hold on to the compassion

Co-chairs letter

Climate change is happening now. The tragic impacts of Cyclone Gabrielle have brought this into starkly devastating focus.

This means we need to adapt to the impact that it will have, at the same time as we attempt to mitigate its worsening. The actions need to be accelerated.

For too long the discussions have been about whether or not climate change is real, whether it is man-made or not, whether it will be as bad as predicted or not. It has been wasted years whilst we waited for the evidence to present itself squarely on our doorsteps with calamitous results.

We wish it wasn't here, but it is and action is needed. We need to take that action to avoid the worst scenario. We need to set ourselves up with the best information, deep wisdom, and kōrero to adapt to whatever future may unfold.

Action is required now, and the below whakataukī can be considered as a call to action – don't just wish for it, do something about it.

Aotearoa New Zealand's farmers, growers and foresters are used to weather. It's what they deal with on a daily basis, and continually have to plan around it. What the scenarios identify is how the extremes will become more extreme and more frequent. More droughts, more heavy rain, more heat, more cold. This impacts on crops, on animals, on ability to sow, to harvest, to birth, and the impacts on community, whanau and individual resilience are already being tested.

He manako te koura i kore ai

Wishing for a crayfish won't get you a crayfish

Our agricultural sector will be at the forefront of the impacts of a changing climate. For many in agriculture, this is not just their business, but their home. This is why this work has been so important.

We started this process in April 2022 and set ourselves an ambitious task to prepare scenarios and a roadmap within a year. Pulling together a Leadership Group and a Technical Expert Group from across the sectors and across the supply chain including horticulture, dairy, forestry, livestock, regulators and strategy specialists has been a journey of understanding for all involved. The scenarios have been confronting, and have forced some discussions about land use, about options, and most importantly about what can be done to adapt and to prevent the worst results from occurring. Some participants have been well ahead on that journey of knowledge and were able to share their path, others were just starting out. As with many things, the kōrero or dialogue and collaboration process has been as important as the outcome.

Putting the foundation of Te Taiao at the heart of what we do has been important. To work with nature, rather than against her. Te Taiao can be a taniwha - fierce and strong. We need to be taniwha in our resolve to address the issues we know already, and what will come - to adapt from where we are, to where we as a sector and people of the land need to be.

The plan now has a greater sense of urgency. Many of our regions and communities have been deeply affected in 2023 already. The roadmap for the sector to avoid the most egregious outcomes is not easy, nor importantly is it independent of time. We can lean on the knowledge of those who have walked before us. We have adopted a framework inspired by tangata whenua values to drive the actions we commit to in our journey ahead.

We have also been very intentional in approaching this with a lens of business risk relating to the climate-related financial disclosures requirements. We specifically call on business leaders to boldly enter these discussions with their suppliers, to build knowledge, awareness and support.

The close relationship between mitigation and adaptation was explored in many sessions in the development of the scenarios and roadmap, especially when adaptation may mean switching to another land use due to a changing climate, or planting for erosion control. These are not easy or comfortable discussions, but the more we understand the context, hopefully the more armed we can all be to make decisions and take action.

All those involved in the process, and the Secretariat, cannot be thanked enough for their contribution to developing the Agriculture Sector Climate Change Scenarios and Adaptation Roadmap. This cross-section of people validates the content and provides confidence in the ability to bring the roadmap to life.

This can be uncomfortable, which is why this document needs to be taken up and used around management tables, board tables, in staff rooms, in marae, and town halls around the motu. We can either sit on our hands and ignore the facts, or we can give it our all and be an example of what can be achieved, which is what our agriculture sector has done time and again.

Our scenarios look forward to assessing what "might be". It would be a tragedy if in 50 years our descendants look back and say "I wish they'd had courage and vision".

Mauri Ora.

Jenny Cameron
MPI

Craig Ellison
Ngāi Tahu Holdings

Project governance

The working group for this project consisted of a tiered governance structure which reflected the diversity of the agriculture sector.

The **Co-chairs** provided governance and oversight of the project and its outputs. The Co-chairs' responsibilities included providing final sign off on members of the Leadership Group and Technical Expert Group, final sign off of outputs and acting, together with the Leadership Group, as the spokespeople for the project to ministers, the media and other key stakeholders.

The **Leadership Group (LG) s**et the ambition for the project and guided and reviewed the work of the Technical Expert Group (TEG). They are leaders in their field and brought mana to the project. The group met on a regular basis to provide input and feedback to the TEG and agree on key decisions throughout the project.

The **Technical Expert Group (TEG)** included technical experts across climate science, the agriculture sector, policy and sustainable finance. The TEG has undertaken key research, stakeholder engagement and development of the Adaptation Roadmap, and ensured co-design with te ao Māori.

The Aotearoa Circle contracted PwC New Zealand to support the development of climate scenarios and an Adaptation Roadmap for the agriculture sector. PwC acted as secretariat, offering climate change expertise, workshop facilitation, report writing, and assisting the development of the adaptation strategy.

The Leadership Group

This kaupapa is lead by a collaboration of industry professionals

Tim Myers
Norwood

Charlotte Rutherford
Fonterra

Kate Beddoe
Silver Fern Farms

Kerensa Johnston
Wakatū Incorporation

David Chin
LIC

Craig Pattison
ChalknTalk

Dr Paul Johnstone
Plant and Food Research

Dr Abby Thompson
Food HQ

Nick Allison
Carrfields

Geoff Smith
Scales Corporation

Rachel Depree
Zespri

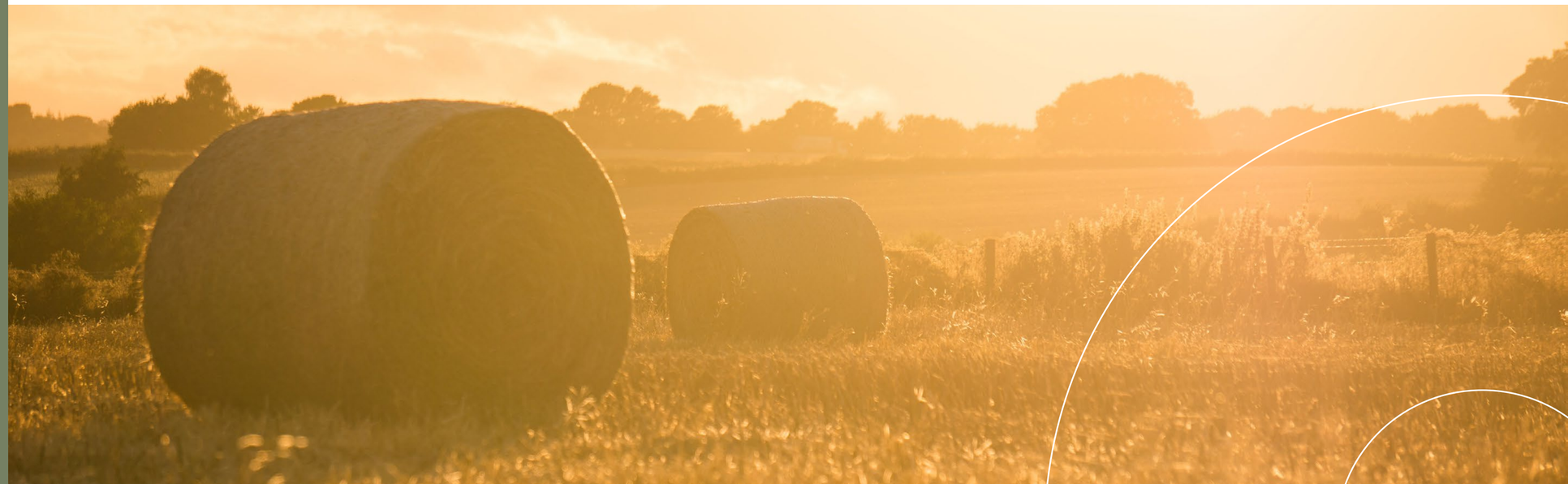
Mark Leslie
Pāmu

John Morgan
NIWA

Mavis Mullins
EPA

Siobhan O'Connor
FENWICK

Dr Fiona Carswell
Manaaki Whenua
Landcare Research



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Key Concepts and Definitions

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Indigenous practices / knowledge

The understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For many indigenous peoples, indigenous knowledge informs decision making about fundamental aspects of life, from day-to-day activities to longer-term actions. This knowledge is integral to cultural complexes, which also include language, systems of classification, resource use practices, social interactions, values, ritual and spirituality. These distinctive ways of knowing are important facets of the world's cultural diversity.[1]

Kaitiakitanga

Guardianship and protection of our natural, built and cultural resources for the benefit of current and future generations.

Mauri

Life principle, life force, vital essence, special nature, a material symbol of a life principle, source of emotions – the essential quality and vitality of a being or entity.

Protein diversification

The transformation of existing and future portfolio composition by shifting away from an over-reliance on resource-intensive animal proteins towards lower impact protein ingredients and products. These can include plant-based, cell-cultured, fungal-based and whole-plant alternatives to meat, dairy, seafood and other animal proteins.[2]

Regenerative practices / regenerative agriculture

An approach to land management that recognises how all aspects of agriculture are connected through a network. This differs from a linear view of agriculture as a supply chain. The principles behind regenerative agriculture are meant to restore soil and ecosystem health, address inequality and leave our land, waters and climate in better shape for future generations.[3]

Resilience / resilient practices

The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, by responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it allows systems to maintain their capacity to adapt, learn and/or transform.[4]

Sustainable finance

Sustainable finance is the process of taking due account of environmental, social and governance (ESG) considerations when making investment decisions in the financial sector, leading to increased longer-term investments into sustainable economic activities and projects.[5]

Sustainability / sustainable practices

Describes conditions where natural and human systems can persist. Ecosystems continuously function, biodiversity is high, natural resources are recycled and, in society, people successfully apply justice and equity.[6]

Rangatiratanga

Upholding the mana of the people in all we do, empowering ourselves and those around us and leading by example.

Taiao

The land, water, climate, and biodiversity that contains and surrounds us all.

Te Ao Māori

The Māori world view and interconnectedness of living and non-living entities.

Whakatauki

Māori proverb or formulaic saying. Whakatauki creates meaning in our story.

1 Ministry for the Environment. (2022). *Aotearoa New Zealand's first national adaptation plan.*
2 Jo Raven. (2020). *The Road to Protein Diversification for Global Food Companies.* FAIRR Initiative.
3 Ibid #2
4 Ibid #2
5 European Commission. (2023). *Overview of sustainable finance.*
6 Ibid #2

Context and Objectives

Context and Objectives

The challenge

Agriculture is New Zealand's largest sector of the tradeable economy, but it is vulnerable to the impacts of climate change. More frequent extreme weather events, such as recent cyclone damage across large parts of the North Island, flooding in the West Coast and Marlborough regions of New Zealand, prolonged droughts in areas such as Northland and the Hawke's Bay, and late frosts that can damage fruit harvests all impact on food production to some degree.

In New Zealand, much of the public and private sector climate change action to date has focused on mitigation to meet our international and domestic targets. However, as the agriculture sector faces unprecedented levels of climate change it needs to build resilience, deepen its awareness of the risks that climate change presents and further understand how climate change will impact food production under different temperature scenarios and associated impacts. To do this successfully, the sector must come together like it hasn't before.

The opportunity

As the sector continues to experience disruption from climate change on a more regular basis, there is an increasingly urgent need to create a roadmap for change. The Agriculture Sector Climate Change Scenarios and Adaptation Roadmap can support the industry's ability to respond to the impending challenges of climate change. It can also provide tools for industry and sector participants (farmers and growers) to develop an adaptive, resilient and sustainable industry that will continue to flourish in an uncertain and ever-changing world.

The outcomes from this work build on New Zealand's first National Adaptation Plan (NAP) that was released in 2022: this work provides support to sector stakeholders to respond to the policies and measures set out in the NAP. At the same time, sector level risk assessment and scenario analysis is being encouraged by the External Reporting Board (XRB) under the mandatory Climate-related Disclosures (CRD) regime. This work provides a useful reference for companies captured by the regime.

In order to enable the CRD disclosures, the XRB has developed standards and guidance for climate reporting entities (CREs). The XRB has encouraged sectors to collaborate to develop shared sector-level climate scenarios. This collaborative approach supports the development of robust scenarios that are decision-relevant for the agriculture sector and will enable a level of consistency and comparability across individual sector participants. It also provides a platform to bring the sector together to consider the future and how to embed sustainability in operations, while building resilience to climate change.

Objectives

The following overarching objectives guided the development of the Agriculture Sector Climate Change Scenarios and Adaptation Roadmap.

1

Translate climate and socioeconomic projections into operational, commercial and social implications for the sector.

Output:
Agriculture sector-relevant climate scenarios, and sub-sector specific risks and opportunities identified, to support the sector in considering future climate change outcomes and implications.

2

Give visibility to the challenges faced by the sector in developing and implementing their approach to climate change adaptation.

Output:
A clear understanding of the barriers to adaptation and the implications of those challenges.

3

Highlight opportunities and recommend actions for addressing the challenges and supporting the sector to adapt.

Output:
A practical and pragmatic Adaptation Roadmap that prioritises the actions that will have the greatest impact in supporting the sector's adaptation to climate change.

Defining the agriculture sector

New Zealand's agriculture sector is diverse and extensive and is worth $55bn per year in export revenue to the economy. In 2022, the food and fibre sector accounted for 81.4% of our trade and 10.7% of GDP.[7] Core participants in the agriculture sector include farmers and growers providing "the world's most discerning consumers with outstanding, ethically-produced food, natural fibres, drinks, co- and bioproducts."[8] In addition, there are participants that provide crucial inputs to the sector and participants providing logistics and other essential services.

Due to its complexity, it was necessary to define the New Zealand agriculture sector to ensure this work was relevant to as many industry players as possible. The agriculture sector value chain as defined for this work is captured in Figure 1. This figure reflects the consensus reached to determine the large elements of the agriculture value chain but may not be exhaustive.

Figure 1: Agriculture sector value chain

	Core Agriculture		Beyond Agriculture		
Inputs	Production	Processing	Logistics	Service Providers	Waste Disposal
Equipment (incl. feed) Fertiliser Seeds Irrigation Labour Finance Animal Genetics Energy Agriculture Advisory Services	Beef / Sheep / Deer Dairy Horticulture Crop Forestry Pig Poultry Nurseries Viticulture	Slaughterhouses Packhouses Dairy Processors Machinery Suppliers Packaging Food Manufacturers	Freight Traders / Exporters Storage Cold Chain	Food Retailers International Markets Food Services Consultants, Land / Stock Agents Wholesalers	Waste Management
Influencers	Local Government	Central Government	Primary Sector Relevant Ministers	Industry Bodies	Regional Economic Development Agencies
	International Markets	Tangata Whenua	International Think Tanks	Farm Consultants	International Bodies
Wider value chain	Mana Whenua	Nature	Customers	Communities of NZ	Research Institutes
	Workforce	Finance Institutes	Brand NZ	Infrastructure	

7 Ministry for Primary Industries. (2022). *Situation and Outlook for Primary Industries.*
8 Fit for a Better World. (2022). *Accelerating our economic potential. Ministry for Primary Industries.*

The agriculture sector subsystems

Dairy

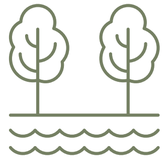
Around 50,000 people are employed in the dairy farming sector, on and off farms generating $3.4 billion in wages in 2019. The sector is a significant employer in many districts, for example accounting for up to a third of jobs in Waimate and a quarter in South Taranaki and Otorohanga. Dairy farmers spend approximately $15b in New Zealand, while processors purchase $8b of goods and services in New Zealand.[9] The sector directly contributes $10.2b to New Zealand's economy each year. Dairy export revenue is forecast to increase by 6% to reach $23.3b in the year to 30 June 2023.[10]

Sheep and beef

New Zealand's red meat industry employs approximately 92,000 people and earns around $4.6b in household income. The sector contributes nearly $12b to New Zealand's GDP and red meat exports account for 16% of New Zealand's total exports.[11] The industry makes up 12% of the regional economy in Otago and Southland, and 10% in Taranaki and Manawatu/Wanganui. Export revenue is forecast to increase 1% to $12.4b in the year to 30 June 2023.[12]

Broad acre cropping

Broad acre cropping, or arable production, adds about $1b of value to the New Zealand economy each year, delivering about $5b to the wider food industry in raw materials. Arable farming operates on 131,000 hectares of New Zealand land and employs people throughout New Zealand. Arable export revenue is forecast to increase 5% to $265m in the year to 30 June 2023.[13]



Horticulture

Horticulture includes fruits, vegetables and garden crops and ornamental plants. The sector employs over 60,000 people annually and is worth more than $6b to the New Zealand economy. Horticulture employs people in fruit and vegetable growing, harvesting, production, distribution and marketing within New Zealand and globally. Horticulture export revenue is forecast to increase 5% to $7.1b in the year to 30 June 2023.[14]

Forestry

Forestry employs around 35,000 people in wood production, processing and the commercial sector. Wood products are worth $6.7b in exports to New Zealand, making up 1.6% of GDP. Forestry exports are forecast to increase to $6.6b in the year to 30 June 2023.[15]

9 DairyNZ. (2020). *New analysis highlights dairy's economic contribution.* NZ Herald. DairyNZ Submission to the Productivity Commission Inquiry. (2020). *Immigration, Productivity and Wellbeing Inquiry.* Sense Partners. (2020). *Dairy's economic contribution: 2020 update.* New Zealand Productivity Commission. (2020). *The dairy sector in New Zealand: Extending the boundaries.*
10 Ministry for Primary Industries. (2022). *Situation and outlook for primary industries.*
11 Beef + Lamb New Zealand, Meat Industry Association of New Zealand. (2020). *The red meat industry's contribution to New Zealand's economic and social wellbeing.*
12 Ibid. #11
13 Ibid. #11
14 HortNZ. (2023). *Jobs & labour.* Horticulture New Zealand.
15 Ministry for Primary Industries. (2022). *Forestry and wood processing data.*

Te Ao Māori Framework

Traditionally, a whakataukī was wisdom passed down through the ages, as guidelines in speeches or at less formal occasions. It should embody the values, wisdom and wit of tangata whenua, and be concise to convey key messages. The Agriculture Sector Climate Change Scenarios and Adaptation Roadmap is an important document, so it is entirely appropriate that two whakataukī have been used to open and close this Te Ao Māori framework.

He manako te koura i kore ai

Wishing for a crayfish won't get you a crayfish

Climate change is happening now. It needs hard work and deep wisdom to diminish the environmental, societal, and business impacts. The measures recommended by this Adaptation Roadmap will go some way to see the extremes avoided. This work recommends an eyes wide open approach to scenarios as the indicators of how Aotearoa New Zealand may be affected in the short and medium term. The roadmap for the sector to avoid the most egregious outcomes is not easy, nor importantly is it independent of time. Action is required now, and the above whakataukī can be considered as a call to action - **don't just wish for it, do something about it**.

This framework builds on the Te Ao Māori framework that was adopted by the Mana Kai initiative, using a crayfish trap as the symbology. It is a Māori view that the connections are real and significant between our food system, the land, our natural and altered environments, and the people. The Aotearoa Circle launched the Mana Kai Initiative last year, a national conversation to ensure we enhance and protect Aotearoa New Zealand's food systems. With kōrero at its core, Mana Kai is grounded in Te Ao Māori wisdom. A Mana Kai Framework has been developed as a starting point for kōrero. The framework is outlined below. [16]

Mana o te Whenua

Natural energy of the environment

Mana o te Whenua focuses on the environmental factors that impact on the production of food, both in the wild and through human assistance (i.e. agriculture, horticulture etc). Mana Whenua also factors in the need for humanity to change behaviour to ensure we tackle environmental issues, particularly climate.

Whenua is the physical manifestation of Atua. Through our shared genealogy we are related to the environment and must treat it in a way we would expect to be treated in a familial relationship. It is through the communication with and treatment of the Mana o te Whenua that we practise true kaitiakitanga through guardianship and giving back to the natural world.

Mana Kai

Sustenance from food

The connection of Atua like Tangaroa with the ocean and Rongo for cultivated food is an essential part of how we pay deference to the environment, for what it provides and our relationship as food producers with the food we produce.

As an example, a farmer will have a respect for the land that may not be obvious to environmentalists, but is a respect based on the knowledge of their land, localised climatic factors and the relationship they have with special places on their farm. This all contributes to Mana Kai, and often farmers have taken direct steps to improve mana whenua.

Likewise, respect for animals may be strongly evident as part of the slaughter process for animals. This also contributes to Mana Kai because there is a consciousness associated with the mana of living things and knowing that you are taking a life, a respect and connection between Tuakana-Teina moves past theory where we make the death a quick and humane death.

Mana o te Tangata

Harvesting and fair distribution of food

Mana o te Tangata, in this context, is about how we care for each other and the importance of fair distribution. Mana of te Tangata focuses on the need to care for the whole of humanity and ensure that there are no groups of people disadvantaged or forgotten throughout the food system.

Mana o te Tangata aligns with the Sustainable Development Goals of the United Nations. In fact, Mana Kai necessitates that societal goals and food goals are the same and not different. This will require a whole of system approach rather than only a food system approach.

16 The Aotearoa Circle. (2022). *Mana Kai initiative.*

"Our challenge is to transform from manaia to taniwha, from passive guardians to fierce advocates for the changes we endorse."

The Agriculture Sector Climate Change Scenarios and Adaptation Roadmap acknowledges Mana Kai's work and has used it as a basis and inspirational guide for this Te Ao Māori framework.

The Adaptation Roadmap is a kōrero or dialogue and collaboration, involving all parts of our agriculture sector value chain, from farmers to regulators, advisors, and suppliers. It asks them to consider a range of scenarios that might occur, and to prepare the sector for how it might and indeed, should respond. Scenario analysis is a useful method to test and retest thinking and readiness for action. We embrace enhancing our awareness of the now by looking forward - to embrace the view of mana - for the land, for the people, and for the future. Data will drive the positioning of where we are, and where we need to be. The sense of respect and connection to our environment will drive the desire to restore the mauri. The sector leadership has the opportunity to craft strategies and importantly, actions to secure and restore the mauri.

That drive cannot be passive: we need to be taniwha in our advocacy - deeply caring yet strong, fierce and ambitious in desire to protect and adapt from where we are, to where we as a sector and people of the land need to be. Manaia can be a symbol of guardianship, of the fruits of the land and the labour of the people. The challenge was to see ourselves (the leaders in this work) as the guardians or manaia, but not accepting of that title or role. Taniwha are often assumed to be the 'monsters' of Māori mythos, but taniwha are also hugely powerful protectors of places, tribal taonga and tribal members. They are fierce, resolute and determined and their presence brings peace and security. Our challenge is to transform from manaia to taniwha, from passive guardians to fierce advocates for the changes we endorse. The gift of the taniwha is time. We must not squander it. We must have the ambition to test our vision and implement it. **The taniwha is not 'giving' us our ambition - it is demanding we take it!**

If this framework instils a sense of urgency, it goes some way to achieve the goals and aspirations embedded in the mana of land, people and food. We nourish the soul as well as the puku! For a long time the agriculture sector, through the intensification of agriculture practices, has been syphoning off the mauri of the whenua, and the consequences of that are becoming more apparent. Encouragingly, there are some practitioners who are finding ways to balance the environmental (mauri) and business drivers. Those practices need to be shared and listened to. The imperative to restore the mauri must drive us all, and we need to assess the actions we have taken (or not taken) and ask ourselves - **does what we do advance restoration?**

We cannot simply sit back and wish for technology to solve it all, technology will no doubt be a great help, but it is not our crayfish.

Like the Mana Kai framework, there is a whakapapa that looks forward and back; to endure it needs to evolve and grow. It is not a stratagem for prohibition or preservation but rather an approach of optimism and challenge that is inclusive and strong.

As we opened, so too shall we close with an appropriate whakataukī.

Toitū te ahu whenua
Pūmau ai te kākano

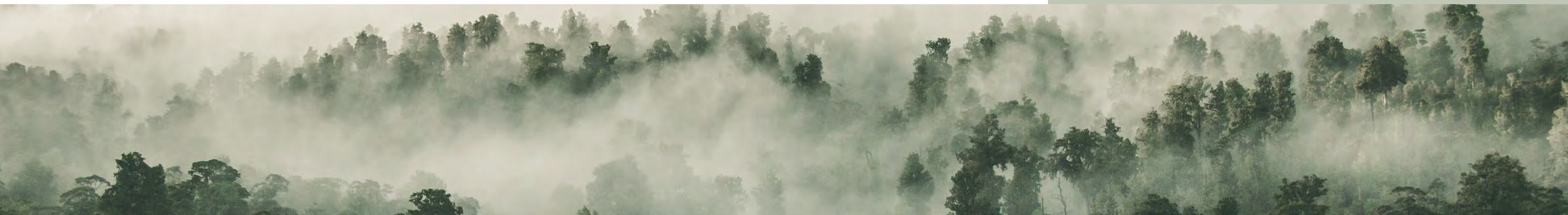
Toitū te ahu moana
Pūmau I te hua

Toitū te ahu ngākau
Pūmau ai te aroha

Sustain the cultivation
of the land
Hold on to the seed

Sustain the cultivation
of the oceans
Hold on to the essence

Sustain human growth
Hold on to the compassion



Te Taiao guiding principles

In the way that we have borrowed our Te Ao Māori framework from Mana Kai to ensure this scenario analysis and adaptation roadmap is connected to New Zealand's food system, we have borrowed our guiding principles from 'Fit for a Better World'. Fit for a Better World is the vision created for New Zealand's primary sector founded on the wellbeing of Te Taiao, the natural world, and genuine and transformative partnerships. Te Taiao represents a deep relationship of respect and reciprocity with the natural world.[17]

By adopting the guiding principles of Te Taiao, we will ensure the Adaptation Roadmap we have developed puts the wellbeing of the natural world at its heart. It will ensure that we focus on the impact and influence of all our actions, as we follow the pathway to transformative change across our agriculture sector and drive the desire to restore the mauri of our land. To drive real commitment and to preserve the integrity of Te Taiao, leadership is required.

The foundations of Te Taiao are three kawenata (principles) that guide everything we do and four pou (pillars) that help us understand the different realms of Te Taiao and their interconnectedness.

Taiao ora, Tangata ora

If the natural world is healthy, so too are the people

Figure 2: The guiding principles of Te Taiao

17 Fit for a Better World. (2022). *Taiao.*

Agriculture Sector Scenarios

Introduction

Guide to using climate scenarios

Understanding an uncertain future

Projecting the physical and transition impacts of future climate change is highly uncertain. Climate scenarios allow us to give structure to this uncertain future. Instead of trying to predict the future, they paint broad pictures of how the future could look, and in doing so create a rich evidence base for testing the resilience of the sector to climate change and to the challenges it could bring. According to the Task Force on Climate-Related Financial Disclosures (TCFD), "*in a world of uncertainty, scenarios are intended to explore alternatives that may significantly alter the basis for "business-as-usual" assumptions*".[18]

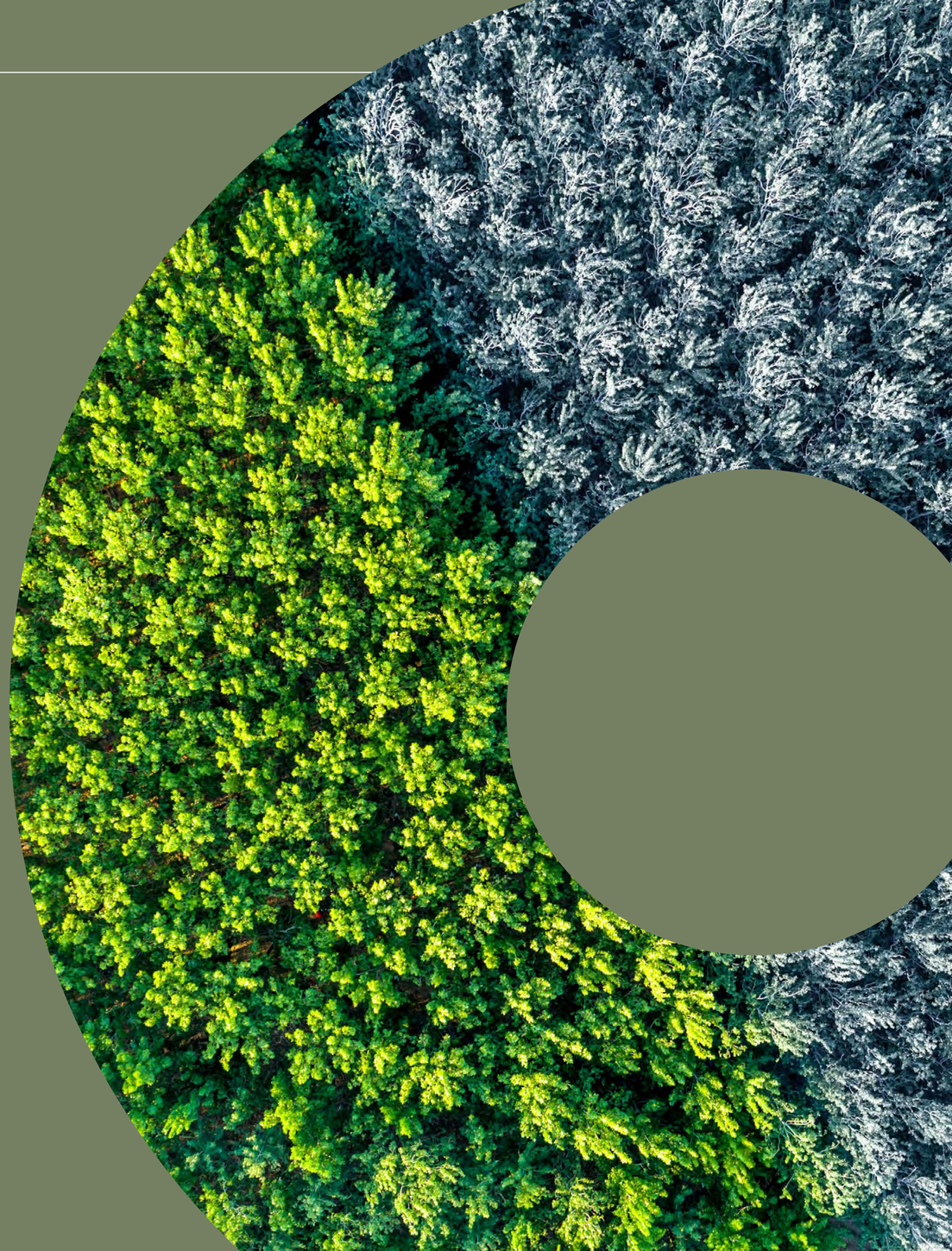
Under the Climate Standard released by the XRB in late 2022,[19] Climate Related Entities (CREs) are required to perform scenario analysis to better understand climate-related risks and opportunities for their organisation. To ease the burden on individual organisations, the XRB has recommended that sectors come together to develop shared scenarios that CREs within the sector can use. The intention of the shared sector-wide scenarios is to ensure consistency and comparability in disclosures across each sector. Sectoral collaboration will also "*provide greater comparability and lead to higher quality scenarios, while imposing fewer resource demands for CREs*".

To meet the requirements set out by the XRB, CREs must analyse at least three scenarios: a scenario in which global warming is limited to 1.5°C, a scenario in which warming exceeds (or is on track to exceed) 3°C and one other of the organisation's choosing. This span ensures that resilience is being tested to both the physical and transition risks it could face in the future.

What are scenarios?

Scenarios should enable us to think critically about how the sector currently operates and how that operating model can improve its resilience to the challenges the future will bring. The TCFD cites five characteristics of high quality scenarios:

- **Plausibility** - scenarios should be credible, possible and believable.
- **Distinctiveness** - each scenario should include a different combination of key factors and provide differentiated messages.
- **Consistency** - scenarios should have strong internal logic, where interactions between factors, actions and reactions are consistent across scenarios and able to be logically explained.
- **Relevance** - scenarios must be decision relevant. They should provide insights that enable dynamic risk management and strategic planning.
- **Challenge** - scenarios should challenge conventional wisdom and simplistic forward thinking. They should aim to incorporate alternative pathways that challenge current assumptions.



18 Task Force on Climate-Related Financial Disclosures. (2017). *The use of scenario analysis in disclosure of climate-related risks and opportunities.*
19 External Reporting Board. (2022). *Climate-related disclosures framework: Consultation document.*

Using scenario analysis to inform dynamic risk management

A robust strategy is more than a specific company's emissions target or pathway; it is an approach that recognises uncertainty, provides flexibility, and can respond appropriately to the future as it unfolds.[20]

Key steps to implementing scenario analysis informed by the TCFD guidance:

1. Introduce the concept of scenario analysis to board members and senior management

If scenario analysis, or climate risk broadly, is not already a core part of the organisation, time should be spent educating senior management and board members on the basics of climate change and how scenario analysis can improve organisational strategy. This may require experts from outside the organisation coming to speak or provide other educational material.

2. Establish the governance and work structures, and the scenario team

Bring together a 'scenario team' that spans the organisation's operating model and includes sufficient representation from the executive team to ensure buy-in for the project. Determine who will be ultimately responsible for the work and who will be accountable for implementing any actions that emerge through the process.

Ideally, the leader should be a senior staff member from the strategy or sustainability team. Facilitation and administration are important roles throughout the process, as they stimulate an open and challenging environment, maintain internal communications and ensure progress is made within time and budget constraints.

Determine if external assistance is required to fill any capability or resource gaps within the organisation.

3. Mobilise

Begin the scenario analysis process by identifying the focal question for the analysis. For most organisations, a simple and broad question such as 'how could climate change plausibly affect our organisation?' is an ideal place to start. It's critical to link in with the risk and opportunity function to ensure they are included in the scenario analysis process.

The early parts of the scenario analysis process are centred around understanding how the business operates, what its strategic goals are, its key operating markets and environments, and how decisions get made. Identify key gaps in the available information that need to be filled.

4. Explore the impacts on the business

Using the scenario narratives in this report, develop targeted narratives that explore how your organisation fits into the picture. Do not assume any adaptations are taken at your organisation, but instead aim to understand how the changed world impacts on the organisation's ability to operate.

You may wish to include some detailed quantitative modelling at this stage. However, be conscious that, as the TCFD wrote, "excessive focus on quantification permeating stakeholder discussions or scenario team deliberations can impair strategic thinking." Be sure to incorporate uncertainties that cover the wide range of plausible future outcomes.

In particular, identify and assess impacts on the business' operations, strategy and financial planning. Explore how these impacts create risks and opportunities for the organisation, and what are the key drivers behind them. The TCFD recommends asking the question "How would our company's existing (or proposed) strategy likely perform under each scenario if it were true?"

5. Identify options and strategy

Conduct thought experiments that explore how existing or proposed strategies, decisions or actions would perform under each scenario. This is an important and challenging step, as it requires organisations to place their own internal visions for the future in the context of the wide range of plausible future outcomes. It's critical to think broadly here and challenge existing assumptions and processes.

Develop options that address the implications of different actions and strategies in the scenarios. Think about the timeframe for each option, its likelihood of success and the materiality of the impact it addresses. Articulate the strategic focus of each option, the scope of its implications and how it could be initiated.

Evaluate strategic options using a set of criteria that accounts for alignment with the organisation's overall vision, its risk appetite, the value generated by the option and the organisation's ability to execute the option. Recognise the uncertainty illuminated in the scenarios by building flexibility and dynamism into strategic options.

6. Implement a review and repeat proces

The scenario analysis process should not be a one-off project. Integrate this process into the organisation's operations by reviewing the analysis for information gaps, biases or blind spots at its conclusion, and developing structures for ongoing analysis. These structures could include in-house capability building or modelling, risk management processes and disclosure.

Scenario development process

The scenarios detailed in this report were developed across three workshops with the Technical Expert Group (TEG). Each workshop built on the previous one and allowed us to build up decision-relevant scenario narratives.

Figure 3: The scenario development process

20 Task Force on Climate-Related Financial Disclosures. (2020). *Guidance on scenario analysis for non-financial companies.*

Climate-related risk assessment and identification

Definition of physical and transition risk

Physical risks are risks arising as a result of chronic changes to the climate such as rising sea levels and warming temperatures, in addition to acute and extreme weather events such as droughts, flooding.

Transition risks are risks arising from the process of adjusting to a low carbon economy or adapting to the impacts of climate change.

Risk and materiality assessment

The most significant risks are included in the table. These were identified through a workshop with the Technical Expert Group (TEG) and confirmed in discussions with the Leadership Group (LG) and Co-chairs.

Table 1: The most significant risks to the sector

Physical risks
Inability for existing practices to maintain productivity and output
Increased volatility in production and reduced ability to get product to market
Inability for agriculture industry operators to access financial products
Increase in pests and diseases
Increased water stress and lack of water security

Transition risks
Inability for the sector to develop a whole system approach to build resilience for effective adaptation
Inability for the sector to keep up with the rate of global technological change
Loss of identity and degradation of mauri for rural communities and agricultural sector operators
Policy becomes misaligned with the needs of the sector and how it operates
Inability to maintain public acceptance to access and/or operate in key markets
Failure to understand and meet changing consumer preferences in the market

Drivers of change

Drivers of change (sometimes referred to as driving forces) are critical trends or influences that affect how the agriculture sector operates. They are usually large-scale, exogenous factors that impact how climate risks and opportunities cascade through the agriculture sector. Drivers of change are a key input into climate scenarios. According to the XRB, "understanding which driving forces will have the greatest influence in shaping outcomes for the sector is an essential step in creating climate-related scenarios."[21] By exploring how the drivers of change could evolve and interact in the scenarios, we can build up a picture of how the future could look, and how climate risks and opportunities could flow through the sector.

Through the workshop process, stakeholders identified a number of drivers of change that will affect the agriculture sector in the future. Through the workshops, the TEG and LG acknowledged there were several more significant drivers of change that have the potential to drive more change and impact in the future than others. These drivers of change can be grouped into five broad categories:

1. **Environmental**
2. **Markets**
3. **Policy**
4. **Social**
5. **Technology**

Table 2: The top drivers of change

Drivers of change	Category
Competition for land and water use	Environmental
Severe acute and chronic weather events	Environmental
Access to water	Environmental
Access to capital	Markets
Trade barriers (trade miles / carbon border adjustments)	Markets
Global demand for indigenous products	Markets
New technology advances (accelerated technology capability in alternative proteins, dairy and products - growth of hybrid agri-economy)	Technology
Sustainable farming and nature-based solutions and practices	Technology
Changes to labour force demand and supply	Social
Changing consumer behaviour (demand / preferences / expectations)	Social
Land use change	Policy
Urbanisation of population and growth of cities	Policy

1. Environmental

Physical climate change

The agriculture sector relies on the natural environment. Whether it's bees for pollination, minerals for fertiliser, soil for crops, stable weather patterns for growing conditions or rainfall for water supply, many parts of the sector are intimately reliant on local and distant climates. Weather patterns, the quantity and quality of water available, and how it is spread across the sector and experienced by communities, shape the type and scale of products we farm. In addition, water has cultural significance beyond commercial and recreational use; water imbues mauri and mana and must be handled properly.

It follows that the physical impacts of climate change will have a critical influence on the sector. Although our current and potential irrigated area is projected to decrease, the frequency and severity of extreme weather events, and the amount of water available in each region are key unknowns for the future of the sector.

2. Markets

Maintaining the sector's viability

New Zealand's primary sectors have earned a global reputation as a trusted supplier of quality products and ingredients. With the improvement of sustainability awareness, consumers are now actively embracing products and brands that are environmentally responsible. The changing nature of consumer markets will have a significant impact on the future of the sector. Will animal produced dairy and meat be a viable choice for a new generation of climate conscious consumers? Will trade rules limit high-emitting exports?

Can New Zealand prove its environmental claims both locally and internationally? Will investors, banks and insurers continue to support farm systems with high environmental footprints or that face ever-increasing risks due to the physical impacts of climate change? Asking these questions is fundamental to understanding the future of agriculture in New Zealand.

3. Policy

Sector integration

There is no doubt that the policy and regulation landscape is changing for the agriculture sector. Initiatives such as business-led emissions reporting, He Waka Eke Noa - the Primary Sector Climate Action Partnership to measure, manage and reduce emissions, and the combination of forestry, biodiversity, freshwater and climate policy could have a significant impact on how land is used in New Zealand. Emissions pricing, and incentives for private sector financing could dramatically change the profitability of certain farm systems and practices. They could also affect the price of food, with significant implications for food security. The path the government chooses, the level of consultation with the sector, and the way the sector responds to new policy could lead to widespread land use change over the coming decades.

4. Social

People and communities

Willingness to work in agriculture, appropriate, flexible immigration policies, and the ability to attract talented people will be critical for the prosperity of the sector. Prosperity is an important barometer for the wellbeing of rural communities, especially across the regions. Likewise, views on which land uses are sustainable and which are not, and the demands that consumers put on food production will all play a role in shaping how rural communities evolve in the future. The role that forestry plays in reaching Aotearoa's climate change goals will also be important for determining rural community wellbeing.

5. Technology

Next generation agriculture

Technology has already changed farming over recent decades and the pace of change shows no signs of slowing. But, there is still uncertainty around whether future technology will enable the transition of food production systems from an extractive model to a sustainable one that works for the New Zealand agriculture sector. The balance of these different streams, and the acceleration of alternative protein products, will reflect consumer demand, and private and public investment in R&D. Will organisations invest heavily in innovation to tip the balance in favour of regenerative and sustainable agriculture, and make New Zealand a leader in adapting farming systems to climate change? Similarly, the ability of sector participants to access new technology could vary widely. Affordability, availability, capacity, and willingness of the sector to adopt new practices will all impact how the sector evolves in the future.

21 External Reporting Board. (2022). *Scenario analysis: Getting started at the sector level.*

Impact pathways

To bring the climate risk assessment and drivers of change together, we have developed impact pathways that give us a snapshot of the complex relationship between the aspects of the agriculture sector value chain and how they could be impacted by exogenous changes. Exploring these relationships allows organisations to better understand the complexity and cascading impacts climate-related drivers could have on their business. Importantly, exploring these pathways can enable an organisation to place itself within the complex agriculture ecosystem and recognise how direct impacts on one part of the value chain can flow on to affect the whole sector.

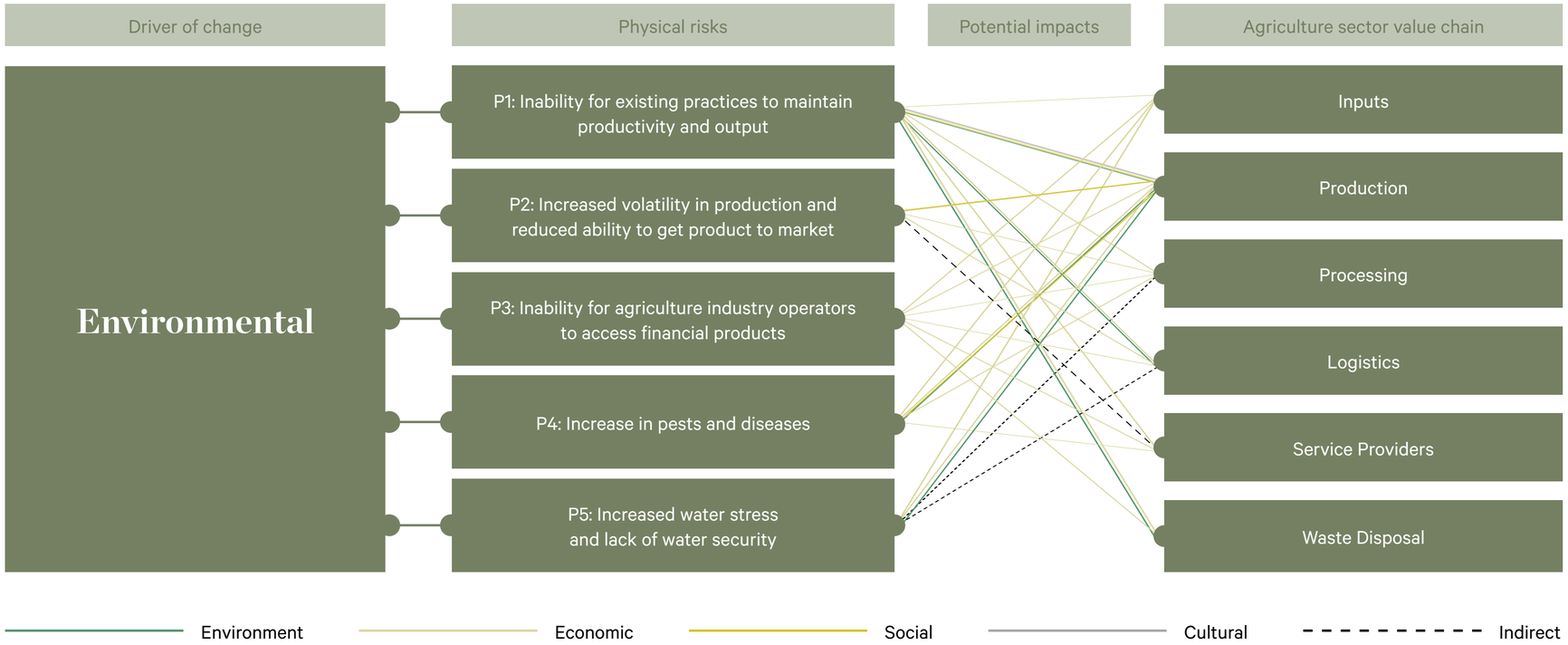
The pathways demonstrate how the most significant risks could impact parts of the value chain. They illustrate that all areas of the agriculture sector supply chain could be impacted if the most significant risks eventuated either directly or indirectly.

Physical impact pathways

Physical impact pathways reveal the parts of the value chain that could plausibly be impacted by risks associated with physical climate change under the environmental driver of change. In the example, we have explored the potential impacts that the top physical risks could have on the agriculture sector value chain.

To note: these pathways are not comprehensive and risks can have other impacts not captured on this diagram.

Figure 4: Physical impact pathways

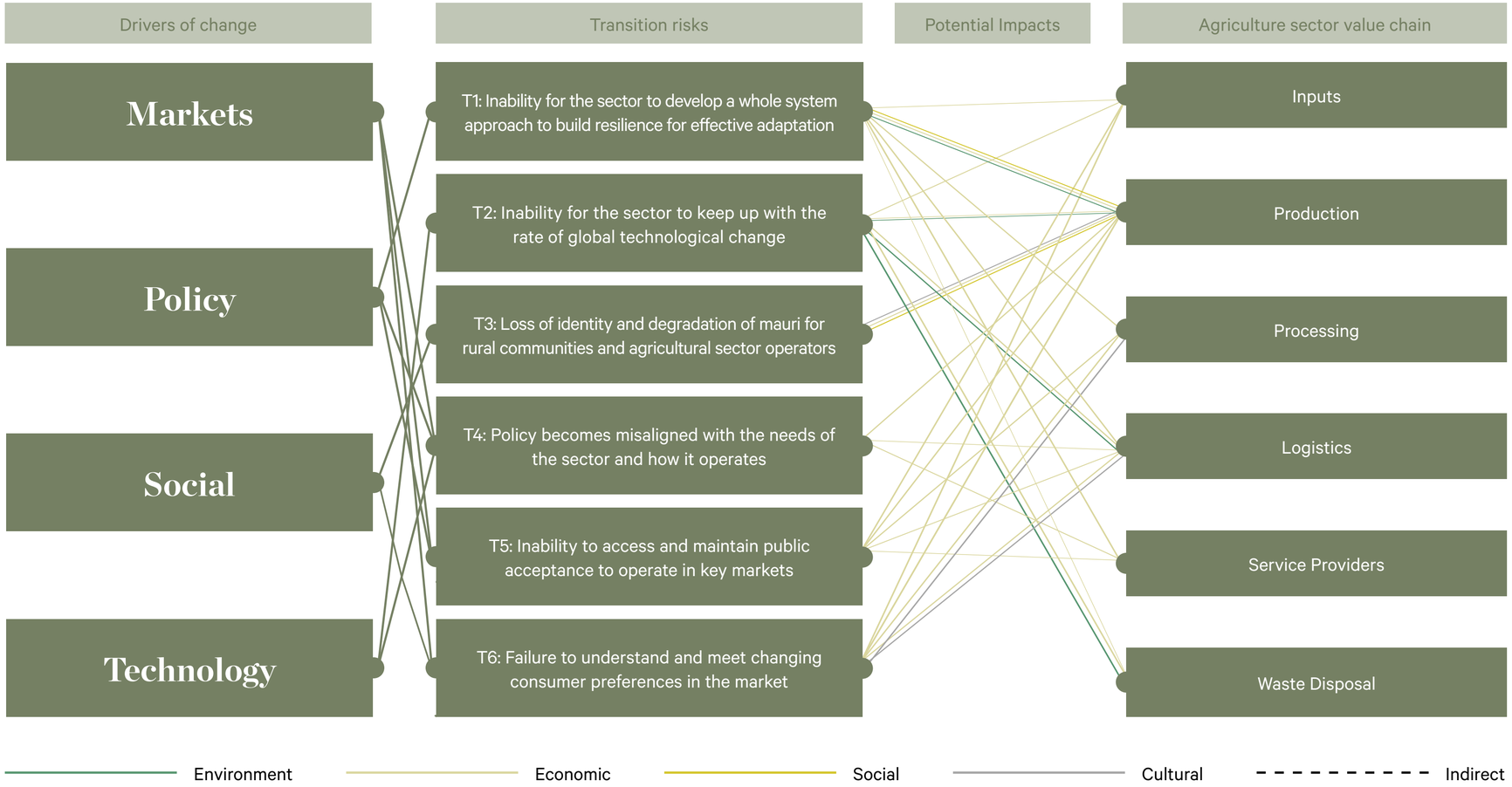


Transition impact pathways

Transition impact pathways reveal the parts of the value chain that could plausibly be impacted by risks associated with transition to a low carbon economy. Because the agriculture sector is complex and deeply interwoven with other parts of the economy, transition risks can lead to complex impacts on the sector.

These pathways are captured under the markets, policy, social and technology drivers and do not attempt to capture all possible paths through which transition risks can cascade, but rather illustrate the systems thinking approach that underpins scenario analysis.

Figure 5: Transition impact pathways



Agriculture Sector Scenarios

Tū-ā-pae, *Stance in order, step in succession* (Orderly)

Tū-ā-pae represents a world defined by a smooth transition to net zero CO_2 by 2050. Global warming is limited to 1.5°C through stringent climate policies and innovation. Tū-ā-pae assumes climate policies are introduced immediately and become gradually more stringent as 2050 looms. Both physical and transition risks are relatively subdued. Achieving net zero by 2050 reflects an ambitious mitigation scenario.

Net zero 2050

The global situation

In Tū-ā-pae, strong and immediate action was implemented in the mid-2020s to tackle the critical environmental and socioeconomic issues facing the world. Living within the earth's planetary boundaries became a policy priority for leaders around the world, shifting to sustainable food systems, sustainable resource consumption, and reducing food waste while safeguarding food security.

Economy

A gradual re-prioritisation of economic goals has occurred so that focus has shifted to broader human and planetary wellbeing. Measures of corporate, national, and global success now include social, environmental and cultural indicators that better reflect quality of life. New trade rules have emerged to drive emissions reductions.

Technology

Research and development into innovative technologies that reduce our material footprint, enhance food security, and increase the efficiency of food production is prioritised. Successful technology must be long-lasting, circular, and highly efficient.

Rural communities

Emphasis on the UN Sustainable Development Goals (SDGs) led to widespread social 'impact' investment, resulting in reduced inequalities across the world. Initiatives to scale up biodiversity and water protection, plus carbon sequestration have strengthened rural communities and driven an increase in jobs and overall wellbeing.

Diets

There has been a widespread shift towards healthy and sustainable diets that include a diverse range of proteins, but proteins from alternative sources predominate. Consumers are increasingly seeking local produce with environmental labelling and provenance stories that embed sustainability.

(SSP1: Sustainability. RCP1.9, RCP2.6)

Aotearoa New Zealand situation

By 2050, we have balanced the reduction of emissions with reversing biodiversity loss, regenerating ecosystems, and improving social outcomes. This earns us global respect. During the transition to net zero, the role of iwi/Māori has strengthened as Te Tiriti obligations are met by the Crown. By adopting a Mātauranga Māori approach to decision-making, New Zealand shows how society can change its relationship with the natural world and incorporate kaitiakitanga into private and public sector policy and procedures.

Early and proactive action from the government and catchment community groups enabled farmers to diversify, build resilience and ensure land use is well-suited to the local climate and soils. Broad acceptance of the need to bolster water security in the face of river and rainfall changes drove investment in equitable allocation and storage schemes.

Physical climate change

The physical impacts of climate change significantly affect the sector, though they are not as severe as in the Tū-ā-hopo and Tū-ā-tapape scenarios. Warmer weather has impacted the vernalisation of some fruit and vegetable crops and changed the suitability of some regions for historically productive land uses. Water availability is becoming more variable, and water security less reliable, while demand for water for food production and processing continues to increase.

Extreme heat has also reduced yields and increased sun damage in some horticulture crops and had an impact on animal and human welfare. Intense rainfall, unseasonal frosts and hailstorms have damaged crops, heightened risks of pest damage and increased challenges for livestock farmers (e.g. to avoid pugging). Sea level rise and storm surge pose risks to coastal and low lying farms, especially those which are vulnerable to saltwater intrusion.

(SPANZ F, CCC Tailwinds)

Key indicators

Tū-ā-pae in 2050 unless otherwise stated

Increase in global temp
1.6°C
Relative to pre-industrial levels

NZ extreme rainfall
+15%
For 2040 relative to 1990

NZ native forestry
0.8Mha
Relative to 2020

NZ sea level rise
0.2m
For 2050 relative to 2005

NZ snowfall
-10 days
For 2040 relative to 1990

NZ carbon price
$277
Per tonne NZD

NZ emissions
6Mt
(CO_2-e)

NZ glacier retreat
-32%
For 2050 relative to 2005

Global population increase
7%
Relative to 2022

Global emissions
26Gt
(CO_2-e)

NZ extreme heat
+15 days
For 2040 relative to 1990

Global GDP
$629tn
(NZD)

NZ population increase
16%
Relative to 2020

Global oil price
$43
Per barrel NZD

Key outcomes

- Effective land use policies and partnerships, starting with He Waka Eke Noa - The Primary Sector Climate Action Partnership which includes measurement, management, reduction pathways, and emissions pricing in the early 2020s, have enabled the sector to build resilience to climate change.
- The sector has been able to reduce its reliance on animal products and shift to a more diversified production system.
- Indigenous and regenerative agriculture practices have been broadly implemented across the sector.
- Iwi/Māori are a strong voice championing ecosystem regeneration in rural areas. Climate data is easily accessible and comprehensive so physical risk assessments are an established part of long-term farm planning. Organisations that have shown themselves to be sustainable and resilient can access affordable insurance.
- Sustainable finance tools and farmer incentive schemes, such as sustainability-linked loans, are common.
- New Zealand has met the emissions reduction targets in the Climate Change Response Act as part of a global push to meet the goals of the Paris Agreement.
- Emissions from the agriculture sector have roughly halved compared to 2020.
- Successive National Adaptation Plans have laid the groundwork for effective adaptation, including supported and planned retreat from some highly exposed regions.
- The physical impacts of climate change have increased water stress in some regions, but inclusive policy enabled farms to diversify or change land use completely and forestry is treated as a bioeconomy. Storm damage still poses high risks across large parts of the country.

Climate Change Commission model outcomes for New Zealand 2050[22]

30%
Smaller dairy herd than 2020

22%
Smaller livestock herd than in 2020

34%
Larger horticulture and arable land than in 2020

30%
Larger exotic forestry land area than in 2020

704%
Larger native forestry land area than in 2020

22 He Pou a Rangi. (2021). *Ināia tonu nei: a low emissions future for Aotearoa.* Climate Change Commission. This data is from the Tailwinds scenario in *Ināia tonu nei: a low emissions future for Aotearoa*, the report written by the Climate Change Commission, as part of their advice to Central Government on the first three emissions budgets and the pathway towards meeting the targets in the Climate Change Response Act. Please refer to the publication for further details on how the numbers were derived.

Changes across the five drivers show how New Zealand has evolved over 30 years in the Tū-ā-pae scenario

Environmental

The post-Covid-19 recovery was centred around meeting the targets set out in the Climate Change Response Act and the new Biodiversity Protection Act enacted in 2030. Land use policies are inclusive, must incorporate non-financial values such as biodiversity protection and restoration, and aim to ensure all parts of society are included in the transition. Local adaptation projects are supported by partnerships through community, local and Central Government and the private sector. Water rights are served by an equitable allocation system that was built on the Three Waters Reform in the 2020s. Through the TNFD disclosure framework, nature-related risks and opportunities are systematically considered in the business strategies.

Reversing ecosystem decline has been a core government objective since 2030. This led to a widespread push to develop and implement regenerative and sustainable farming, growing and forestry practices. Farms, orchards, and forests must show how they are contributing to the ecosystems around them in order to get finance and insurance and satisfy the market. Afforestation pockets on farms, including practices like agro-forestry, are now commonplace.

Markets

The strong consumer shift to incorporate a diversity of proteins into diets pushed the sector to transform. There is still a market for premium, sustainable animal products, in which we are leaders, but the broad shift in demand has driven diversification into high value, low emissions crop and horticulture products. As a result, our food products are sold globally in the premium category.

Banks began to address climate risk in their risk management frameworks in the early 2020s, changing the way the agriculture sector accessed capital. Farmers were incentivised to diversify and adopt regenerative and/or indigenous farming practices through sustainability-linked loans and insurance products. Innovative practices were also encouraged through private and public funding, and some farmers were identified and supported to transition out of agriculture in areas where growing became unsustainable. This created challenges for farms with high levels of existing debt or with owners who were resistant to the change. Some farm operations were not able to survive as the transition gained speed.

Policy

Beginning with He Waka Eke Noa - The Primary Sector Climate Action Partnership in the early 2020s, the sector and Central Government designed and implemented inclusive policies that ensured a just transition. Targets set out in the Climate Change Response Act, the National Adaptation Plan and the new Biodiversity Protection Act 2030 were met. The Mana Kai initiative turned into a National Food Strategy (2030), and a sustainable land-use policy was implemented to support its delivery. The National Food Strategy pushed the shift towards healthy and sustainable diets. Local adaptation projects are supported by diverse partnerships.

Farmers and growers are incentivised to adopt sustainable practices and new mitigation technology. Ambitious, clear, and science-based policymaking and target setting reflects the common goals within and beyond the agriculture sector to address climate change. Cross-sector partnerships add value to public policies and create opportunities to exchange views, supporting innovation and providing extra momentum. Similarly, the commitment to inclusivity meant that rural communities were empowered during the transition, reducing inequalities. National direction on forestry creates a planned and managed approach to balancing productive timber, carbon sequestration and biodiversity.

Social

Throughout the transition, positive outcomes for biodiversity and the economy were realised and pride in the country's agriculture sector grew. Transparency, sustainability, and global success has made the sector an attractive place to work. The widespread incorporation of planetary boundaries into sustainable land-use planning means rural communities are aligned regarding the direction of the sector. The urban/rural divide has shrunk as rural communities have become hubs for land sector innovation. The transition costs are generally high but have varied across sub-sectors. The high cost of replacing old infrastructure assets in 2040 resulted in some dairy farmers with stranded assets unable to transition. Sustainable dairy farms have consolidated and leveraged various monitoring and automated technologies.

Iwi/Māori as significant landowners were positioned as key figures in the transition and products grown using indigenous agriculture methods are in high demand. Visible improvements in health outcomes for the country have also emerged because of the National Food Strategy with lower rates of obesity and heart disease. This shift has come with a raft of societal benefits, including improved mental health, an increase in active transport and community participation and longer life expectancy.

Technology

Since the mid-2020s, technology has advanced quickly with a key focus on driving regenerative practices. Artificial intelligence and precision agriculture have revolutionised harvesting and planting methods. Synthetic fertilisers have been replaced by low cost and low emissions alternatives, and methane inhibitors have been developed to reduce livestock emissions. Significant innovation came out of our research groups who were well-funded by the government and the private sector to strengthen the country's global leadership in agriculture research and development. New plant varieties have been developed to be more efficient and thrive in the new climate.

Coastal shipping, automated or self-driving vehicles, including electric rail and trucks, as well as other innovative freight methods such as drones, reduced the transport-related carbon footprint of the sector to near zero. Plant protein extraction and cell-cultured proteins accelerated and gained mainstream uptake as a result of their contribution to lower-emissions food production. Our commitment to innovation means it has a place in all parts of the new hybrid agriculture economy across premium livestock products, innovative growing methods, and diversified sources of protein.

Effective policy drives climate action and the transition to a net zero world where the agriculture sector thrives

The agriculture sector has been supported to successfully transition into a diverse and sustainable sector. Regenerative practices and mixed farming systems have built resilience to the physical and transition impacts of climate change across the sector. Farmers and growers who have committed to being part of the transition feel supported by the government and feel they are a valued part of the New Zealand economy. Although some farm operations have been lost, thriving rural communities have emerged. Skilled workers are driven to the sector by its strong international reputation.

A balance has been struck between productive agricultural and forestry land, biodiversity protection, emissions reductions, and food security. Climate and land use data has improved and become easily accessible for the sector so that farmers and growers can understand their climate risks, build resilience, and best understand their contribution to achieving net zero. As a result, native forestry has dramatically increased, biodiversity and water quality outcomes have improved, and the sector is prosperous.

Tū-ā-hopo, *Misstep* (Disorderly)

Tū-ā-hopo represents a world with little policy action until after 2030 after which strong, rapid action is implemented to limit warming to 2°C. In Tū-ā-hopo, countries and territories use fossil-fuel heavy policies to recover from Covid-19, so emissions increase, and nationally determined contributions are not met. It is only after 2030 that new climate change policies are introduced, but not all countries take equal action. Consequently, physical and transition risks are higher. This is a costly and disruptive transition.

Delayed transition

The global situation

By 2050, the world has changed dramatically. Strong global action led by China and the USA started to occur after 2032 when some countries had to report on the achievement of their first nationally determined contributions (NDC1). A spate of severe weather events pushed governments to develop robust strategies to reduce emissions to net zero as soon as possible. Business confidence took years to recover from the dramatic introduction of stringent policy.

Economy

Markets are well connected generally, but some countries have introduced trade barriers to drive emissions reductions at pace. Countries that are not playing their part in the transition face higher trade barriers on global markets. Export markets have shrunk as a result. Nationalist policies emerge with a general desire to source goods and services produced locally to reduce emissions.

Technology

Progress on technology was slow until 2032 then accelerated, but with regional discrepancies. The rising price of food leading to food insecurity means the focus is on producing cheaper proteins from a more diverse range of sources. The global shift away from plastics created a market for cellulose products. Policy and regulatory environments in the USA and China have supported investment in these technologies and enabled scale.

Rural communities

Rural communities have had mixed experiences over the past two decades. Urbanisation has increased as smart cities began to emerge, making them desirable places to live. Strong policy incentivising carbon sequestration has led to significant forest growth in rural areas with displaced agricultural sector workers. This has also caused erosion of rural communities, services, and amenities.

Diets

Global demand for cheap sources of protein has risen as the global population increases and food security becomes a priority, particularly in Asia and Africa. However, strong mitigation policy means that demand for low-footprint products has increased since the mid-2030s. Consumers are wanting to buy locally grown, or locally sourced products which are either fresh or lab-grown. A growing market emerges for sustainable, indigenous products.

(SSP2: Middle of the Road. RCP4.5)

Aotearoa New Zealand situation

New Zealand was a 'follower' in climate policy and, therefore, unprepared for the impacts of the transition. The blunt policy interventions to force rapid transition introduced in the 2030s created inequities across society, and between sectors and regions, and depleted the mauri of the country. But, political parties joined forces during the early 2030's to tackle climate change. Iwi/Māori still have a strong voice calling for environmental action and in many regions are seen as a more legitimate source of robust adaptation than governments.

The changing policy landscape and growth in the urban-rural divide left many rural communities underemployed and disenfranchised. Traditional pasture-based farming operations which are resistant to implementing new practices are now considered by many to be unsustainable. Only those that can demonstrate low-emissions production credentials win in the marketplace. The increase in the number of large forestry plantations has led to mixed impacts on rural ecosystems. This has caused a lot of tension around which ecosystems should be protected and what can be sacrificed. Some taonga species have been lost.

Physical climate change

The physical impacts of climate change have become worse and there is now some evidence we have crossed critical climate tipping points. Warmer weather has made some regions unsuitable for growing crops or pasture. Extreme heat has increased across the eastern part of the country, and wildfires are more common increasing risks for the forestry sector. Storms are tracking further south, and regions experience intense rainfall events with a regularity never seen before. Sea level rise and associated storm surge is causing significant problems especially for low lying productive agricultural land that begin to suffer from salination around coastal areas or soil loss and degradation. Severe drought has become much more common across the country, and water-stressed areas are struggling to meet demand. Pests have become more widespread, and diseases have become much more common.

(SPANZ B, CCC Headwinds)

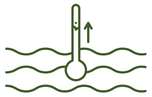
Key indicators

Tū-ā-hopo in 2050 unless otherwise stated

Increase in global temp
2.0°C
Relative to pre-industrial levels

NZ extreme rainfall
+18%
For 2040 relative to 1990

NZ native forestry
0.5Mha
Relative to 2020



NZ sea level rise
0.22m
For 2050 relative to 2005

NZ snowfall
-15 days
For 2040 relative to 1990

NZ carbon price
$369
Per tonne NZD

NZ emissions
24Mt
(CO_2-e)

NZ glacier retreat
-37%
For 2050 relative to 2005

Global population increase
16%
Relative to 2022

Global emissions
57Gt
(CO_2-e)

NZ extreme heat
+20 days
For 2040 relative to 1990

Global GDP
$543tn
(NZD)

NZ population increase
22%
Relative to 2020

Global oil price
$89
Per barrel NZD

Key outcomes

- Operating costs increase due to regulation-related rises in the prices of energy, fuel, transport, and rent. Emissions-intensive businesses quickly face insurmountable challenges.
- The focus on climate change led to biodiversity protection being deprioritised. Only localised biodiversity projects that have climate co-benefits are funded.
- Access to climate data has improved after remaining piecemeal until the mid-2030s. It remains expensive for farmers and businesses to assess their climate risks and transparency is poor.
- Export markets have shrunk as carbon-border adjustments were tightened. New Zealand's animal product exports have dropped off significantly.
- New Zealand failed to meet the first three emissions budgets set by the Government but introduced and met the very stringent budgets set since.
- The physical impacts of climate change have caused damage across the country and adaptation tends to be piecemeal or incremental.
- There is no national strategy or integrated policy for land use or agriculture.

Climate Change Commission model outcomes for New Zealand 2050[23]

17%
Smaller dairy herd than 2020

19%
Smaller livestock herd than in 2020

1%
Larger horticulture and arable land than in 2020

40%
Larger exotic forestry land area than in 2020

459%
Larger native forestry land area than in 2020

23 He Pou a Rangi. (2021). *Ināia tonu nei: a low emissions future for Aotearoa.* Climate Change Commission. This data is from the Headwinds scenario in *Ināia tonu nei: a low emissions future for Aotearoa*, the report written by the Climate Change Commission, as part of their advice to Central Government on the first three emissions budgets and the pathway towards meeting the targets in the Climate Change Response Act.

Changes across the five drivers show how New Zealand has evolved over 30 years in the Tū-ā-hopo scenario

Environmental

As the physical impacts of climate change worsened, New Zealand was unprepared for the challenges it faced. The increase in droughts and floods on farms, and disrupted energy supply and transport routes created widespread issues for the agriculture sector. Adaptation is dominated by incremental rather than transformative changes, with relatively little long-term thinking. Collectives that have worked together to drive transformative change have seen rewards. Access to water is a serious issue in many regions, with large areas left with much less water and some with much more. A market-driven water allocation approach has been implemented, making it difficult for smaller farms to access water. Some farmers lost access to irrigation and were forced to cut down production, diversify, move, or liquidate.

Ecosystem repair and regeneration has not been a priority as focus has been channelled to reducing emissions. While some ecosystems have benefitted from the slowed rate of warming, some were lost as land was appropriated for mainly single variety forestry plantations, the placement of expansive solar and wind farms, and river widening for irrigation schemes.

Markets

The lack of coordinated land use policy combined with changes in consumer demand and high food prices, creates an uncertain operating environment for farmers and growers. The lack of clarity makes investment in parts of the sector risky, particularly in livestock agriculture. Capital is hard to access for regions highly exposed to physical or transition risk such as Hawke's Bay, Canterbury, and Bay of Plenty, but relatively easy to access for forestry, some horticulture projects, and for research and development.

Export markets for animal protein products have shrunk with a rise in protectionism. Although there is still reasonable demand for animal protein, most countries prefer to source it locally due to the perception of reduced emissions. Many countries have introduced stringent trade rules such as carbon border adjustments. These barriers to our exports mean only premium, sustainable animal protein products are viable on global markets. Large numbers of dairy, sheep and beef farmers have struggled to stay afloat. The food miles debate once again becomes prominent and market access is restricted. The diversification of proteins opens new opportunities.

Policy

Government action has driven more people into cities, as job prospects improved in urban areas due to government job programmes relating to the transition. As a result, businesses all along the agriculture sector supply chain have struggled to attract and retain skilled labour. After many years, policy that enables gene editing and selection technology has also emerged, encouraging growers and innovators to develop new proteins, plant breeds and cultivars with a lower footprint that respond to changing climatic conditions. Gene editing has also helped with pest control.

Government policy is often myopic and uncoordinated. There is an increasing burden on the sector to remain prosperous. The rapidly changing financial and consumer world means farmers feel government action is out of step with reality. There is a lack of funding and support for the sector to be a part of the transition. Policy also creates perverse outcomes in some areas. For example, a market-based water allocation approach introduced in 2035 and intended to share water across the sector, led to ‘hoarding’ and an increase in inequality.

Social

The reduction in growth of the sector has reduced the number of jobs available, and its tarnished image has made the sector a less desirable place to work. Both impacts have had flow on social and economic implications for rural communities, and wellbeing has declined in some areas. Parts of the sector that have low environmental footprint or can quickly transition see robust increases in demand and government and private sector support. For example, exotic forestry is further incentivised due to its carbon sequestration and contribution to the bioeconomy, and horticulture has received positive attention due to its low emissions. These subsystems expand and the surrounding regions benefit accordingly.

Mauri in rural communities has decreased as iwi/Māori issues have been deprioritised in favour of emissions reductions. Iwi/Māori remain a strong voice for progressive social change, but Mātauranga Māori is not widely incorporated into public and private sector planning.

Technology

Given the high warming impact of methane, the Government takes steps to rapidly reduce on-farm livestock emissions including with the implementation of effective methane inhibitors in 2035. The methane inhibitors have been effective but are only applicable in systems where feed can be provided to animals, which makes it hard for the beef and sheep industry to compete. Similarly, low carbon shipping methods have been developed, but New Zealand’s distance from the market makes these an expensive transport option.

Advances in agricultural technology to improve productivity have continued. These included new innovations to increase the efficiency of harvesting and milk processing and drying, but their impact has been incremental. New, diversified proteins emerge that are cheaper alternatives to milk and meat proteins. Scaling up of these new proteins is important to feed a growing population.

Although climate data has become more widely accessible, it remains largely decentralised with little government investment. Wealthy organisations can robustly explore their climate risks, but smaller farmers and organisations struggle to access good data and necessary skills.

Rapid and disruptive change sees some parts of the agriculture sector struggle to survive

Around 2030, a sequence of compound weather events swept across the country, causing significant damage to people and property. The most vulnerable parts of the country suffered the greatest losses and food production was impacted heavily. The Central Government responded by dramatically scaling up action to adapt to climate change and reduce emissions, joining the global effort to meet the goals of the Paris Agreement. The associated transition was disruptive and took a toll on the agriculture sector which saw dramatically increased operating and capital costs. As farmers and growers adapt to changing seasons and variability, stranded assets have become an issue through poorly planned land use change.

Consumer demand is still strong for staples and desire for home-grown products gives confidence to the horticulture and broad acre cropping subsystems. But, the incentivisation of exotic forestry by the government through the emissions trading scheme has seen many sheep and beef farms converted to exotic forestry. There is little regard given to protecting biodiversity or soil health. Local meat products remain reasonably popular and competition from a more diversified protein sector is strong.

Tū-ā-tapape, *Faltered step, to fall* (Hothouse)

Tū-ā-tapape scenario describes a world in which emissions continue to rise unabated as no additional climate change policies are introduced. Fossil fuel use continues to increase, and so global CO_2 emissions continue to rise and warming is expected to reach 3°C high by 2080. The physical impacts of climate change are severe. There are irreversible changes such as ice sheet loss and sea level rise. Adapting to climate change has become the priority.

Current policies

The global situation

A series of socio-economic shocks triggered by events such as the Covid-19 pandemic, Russia's invasion of Ukraine and a global financial crisis which saw inflation increase rapidly in the early 2020s, demonstrated the fragility of the energy system. Exploitation of fossil fuels has continued unabated as countries raced to shore up energy supply. The physical impacts of climate change are wreaking havoc. The most vulnerable countries have become uninhabitable, leading to a refugee crisis across low-lying vulnerable nations, especially the Pacific, the Caribbean and Southeast Asia. Geopolitical tensions are very high and supply chain disruptions are common, creating food supply shortages and consequently high costs. The battle for water security has sparked new geopolitical tensions.

Economy

Economic growth is still prioritised by governments and is strong, driven by the exploitation of fossil fuel and other natural resources. Investment in education and healthcare has improved quality of life for some developing countries.

Technology

Technology advances reasonably fast. The push for economic growth and increased productivity has pushed businesses and governments to innovate in more efficient energy technology and storage.

Rural communities

Many rural communities with low adaptive capacity have been devastated by physical climate change. More people are moving to the cities where the focus of transformative adaptation is centred. Food production suffers as rural communities decline, and this exacerbates global food insecurity.

Diets

Consumption of animal products has continued to increase since the 2020s. There is an increased demand for cheap protein to feed a growing population, while the consumption of plant-based foods is driven by health and wellbeing rather than climate.

(SSP5: Fossil-fuelled development. RCP8.5)

Aotearoa New Zealand situation

New Zealand has joined the rest of the world in prioritising food and energy security in the face of an increasingly fractured world. No additional climate policies have been implemented since the 2020s and as a result warming is spiralling out of control. Faced with high costs and disrupted global markets, the focus is on ensuring food production remains high despite the environmental impacts. Population increase has been driven by migration and refugees, placing increased stress on local food systems and access to water.

Emissions from agriculture are still very high by global standards. Livestock agriculture is also under pressure from animal welfare groups due to animal heat exposure and water shortages. But, there is a system-wide shift taking place as the sector must adapt to the worsening impacts of climate change. Chronic climate impacts have changed the suitability of some regions to support land uses. With no government support, farmers and growers struggle to survive. There is a huge demand for cheap food, and we have become a net importer of diversified sources of protein proteins, which become cheaper as they are more widely adopted.

Physical climate change

The temperature has already risen to around 2.5°C above pre-industrial levels and is on track for 3+°C of warming. Tropical cyclones now push further south than ever before and often cause flooding in parts of the North Island, while the South Island is pummelled by the extratropical storm track. The physical impacts of climate change are devastating and becoming worse.

Extreme heat has created health risks for people and animals in warmer regions such as Gisborne, Hawke's Bay and Canterbury, and intense rainfall and hail regularly cause damage across the country. Bridges and roads are frequently washed out on the West Coast and in Southland, cutting off some areas and supply routes for crops and milk. Droughts have led to serious problems in Northland and Auckland, with stringent urban water restrictions introduced. Compound events continue to become more frequent. Intense rainfall following a drought, or fire following a drought have devastated some farm systems.

(SPANZ D, CCC Current Policy Reference)

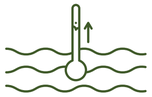
Key indicators

Tū-ā-tapape in 2050 unless otherwise stated

Increase in global temp
2.5°C
Relative to pre-industrial levels

NZ extreme rainfall
+22%
For 2040 relative to 1990

NZ native forestry
0.2Mha
Relative to 2020



NZ sea level rise
0.32m
For 2050 relative to 2005

NZ emissions
40Mt
(CO_2-e)

Global emissions
103Gt
(CO_2-e)

NZ population increase
26%
Relative to 2020

NZ snowfall
-20 days
For 2040 relative to 1990

NZ glacier retreat
-38%
For 2050 relative to 2005

NZ extreme heat
+30 days
For 2040 relative to 1990

Global oil price
$157
Per barrel NZD

NZ carbon price
$35
Per tonne NZD

Global population increase
8%
Relative to 2022

Global GDP
$754tn
(NZD)

Key outcomes

- Severe weather causes frequent damage and disruptions to transport, infrastructure, and food supply. Crops and livestock are damaged and transport routes often fail. Due to climatic changes, yields drop and so do the profitability of farms, impacting long-term viability.
- In some areas, farmer livelihoods cannot be supported leading to either government subsidies or farm abandonment and high food prices.
- Adaptation is the priority and government support is consistent with this. Local governments are empowered to undertake local adaptation projects, but the costs grow inexorably.
- Demand for livestock products continued to grow and the shift to plant-based diets lost momentum in the 2030s. New Zealand's products are sold on global markets only after enough is set aside for domestic consumption.
- Emissions budgets are still set but they are weak and are often not met as they carry little political weight as larger countries continue to emit.
- National Adaptation Plans have become a flagship policy document with a strong focus on transformative adaptation and building resilience.
- Biodiversity protection has not been a government priority for two decades. Energy and food security dominate political decision-making. Soil degradation and loss of critical insect species hamper any efforts to increase productive capacity.

Climate Change Commission model outcomes for New Zealand 2050[24]

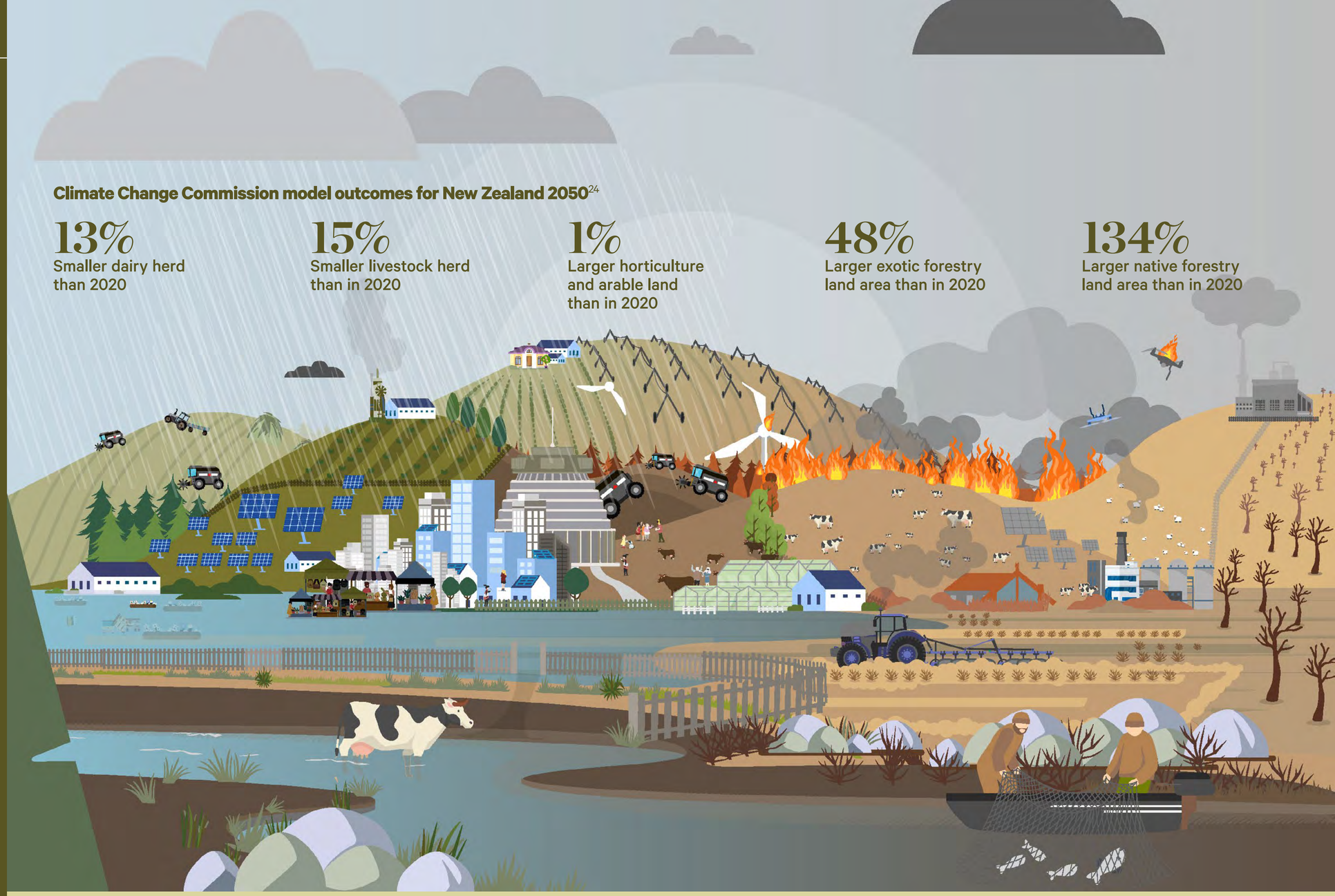
13%
Smaller dairy herd than 2020

15%
Smaller livestock herd than in 2020

1%
Larger horticulture and arable land than in 2020

48%
Larger exotic forestry land area than in 2020

134%
Larger native forestry land area than in 2020



24 He Pou a Rangi. (2021). *Ināia tonu nei: a low emissions future for Aotearoa.* Climate Change Commission. This data is from the Current policy reference scenario in *Ināia tonu nei: a low emissions future for Aotearoa,* the report written by the Climate Change Commission, as part of their advice to Central Government on the first three emissions budgets and the pathway towards meeting the targets in the Climate Change Response Act.

Changes across the five drivers show how New Zealand has evolved over 30 years in the Tū-ā-tapape scenario

Environmental

The physical impacts of climate change have materially impacted every inhabited part of the world, including New Zealand. Heat and drought records are regularly broken as the world rapidly warms and storms ravage communities and farms across the country. Chronic climate changes, including warming, increased variability and changing seasonality have made several productive regions unsuitable for many, or in some cases all, types of agriculture. Drought and intense rainfall have dramatically increased challenges accessing freshwater. Many regions no longer have enough water to sustain irrigation or get too much rain in short bursts to be able to capture and use it effectively.

Sea level rise has caused saltwater intrusion in soils and water sources in low-lying coastal areas. Storms and storm surges regularly wash out key transport routes and disrupt supply chains. The responses to the physical impacts of climate change have involved the adaptation of farming systems in order to survive or transform to more suitable land uses. The loss of productive land has impacted the sector's ability to produce food.

Markets

Apart from a small number of premium products, the advantage New Zealand had in the market has been lost. Food shortages and supply insecurity have led most consumers to place less importance in sustainability and traceability. As a result, much of our competitive advantage is lost. Products are still sold on export markets, though the costs of exporting have risen due to weather-related hazards. There is significant tension around ensuring enough food supply is set aside for domestic consumption. Significant government support and subsidies are required for vulnerable communities.

In many regions, accessing capital and insurance has become extremely difficult. Banks are no longer willing to lend to areas highly exposed to floods, droughts, and heatwaves. Insurance in many areas is either inaccessible or unaffordably high. These areas have seen farms and orchards shrink massively or become unviable. Adaptive and innovative growing methods such as vertical or indoor farming, which conserve water, land, and energy, have become essential food sources.

Policy

Mitigation policy is still centred around the emissions trading scheme, which does not incentivise strong emissions reductions. Government focus has shifted more towards localised adaptation projects, although the cost of adaptation continues to rise. There is a lack of long-term systems thinking in government. Adaptation-focused policy means that the sector is not empowered to reduce its environmental footprint, but funding and resources are available to implement systems more resilient to climate change. There is support available for the inexorably rising costs of adaptation that farmers and growers face, but in some regions adaptive capacity is simply not high enough.

Although New Zealand had some of the strongest biosecurity in the world, it was not prepared for the influx of pests that warming brought. But, after a series of pest-related crop losses in the mid-2030s, policy was implemented to tighten biosecurity and pest control. Although these policies have improved the sector's resilience to pests, they also increased operating costs for many.

Social

The agriculture sector engenders mixed views from the public. In a world rife with food insecurity and water stress, some view the sector as heroes keeping the country fed. In contrast, many more view the sector as key contributors to the planetary crisis we now face, profiting off the rising price of food. The record heatwave of 2038 saw huge numbers of farm workers hospitalised with heat stroke and a small number of deaths. Working in the sector is unappealing and challenges attracting labour are high. Mauri is low in many rural areas.

Demand for food continues to rise and people just want to be fed and no longer care deeply about the provenance or footprint of their food. Government action has increased the divide between Māori and non-Māori by deprioritising Te Tiriti, and some iwi/Māori have taken measures to protect their land and feed their own people. In doing so, many iwi use indigenous farming methods to bring new products to market and ensure their land is used sustainably.

Technology

The lack of investment in technologies that support and enable sustainable production means traditional agriculture's high environmental footprint remains. Innovation has been focused on increasing productivity or adapting to the impacts of climate change. Climate data and technology that allows the sector to understand its risks has remained stagnant since the early 2040s when international progress on climate modelling stopped with the dissolution of the IPCC process. Artificial intelligence and machine learning techniques have enabled more efficient harvesting and planting.

The focus on adaptation has also brought some advances in technology that enable some farms to continue to be productive despite the impacts of climate change. Products such as shade systems for livestock and crop storm shelters have protected some areas. But, these advances were insufficient in many areas to sustain production.

A warming world with no policy interventions has seen food insecurity rise

Physical climate change has affected growing regions around the country. Costs are high for farmers and growers who struggle to get insurance but are still exposed to weather extremes that damage crops, reduce yields and impact transport routes. This is compounded by increased competition for land for housing due to the growing population. Without a cohesive land use policy, food production falls until innovation enabled indoor farming systems begin to thrive and additional types of proteins emerge into the market. Some farmers and growers have been able to diversify by adopting mixed or innovative farming systems. These farmers and growers have been the most successful in the face of climate change. But, investing in innovative systems such as indoor or vertical farming comes at a high cost and many farm operations could not transition quickly enough to remain viable.

Exports are high, but instead of being a priority for food production as in the 2020s, supplying the domestic market takes precedence which yields lower incomes for farmers and growers. Community tension over lack of water control and who should have priority access, led to the introduction of the Water Allocation Act in 2032, which aimed to shift water from wet to dry regions. However, the Act did not appropriately recognise the needs of ecosystems and although it has helped prolong intensive agriculture in some areas, it has led to devastating impacts on biodiversity.

The regions will be inequitably affected by climate change

We undertook regional level deep dives with subsystem leaders, to consider how the subsystems would be affected by regional variability to future climate change and how this could in turn impact agriculture productivity across the regions.

Three regional case studies were completed in Hawke's Bay, Gisborne and Canterbury. These are three regions where the agriculture subsystems are extremely exposed to climate related risks.

Hawke's Bay

	RCP2.6	RCP4.5	RCP8.5
Mean temperature (°C)	0.7	0.9	1.1
Hot days (days)	8.8	11.3	14.1
Precipitation (%)	-1	-1	-2
	Strong drying in winter and spring		
Extreme precipitation (%)	9	12	15
Drought	Small increase	Moderate increase	Very strong increase

All information is from the following sections of MfE Climate Change Projections for New Zealand (2018):[25]

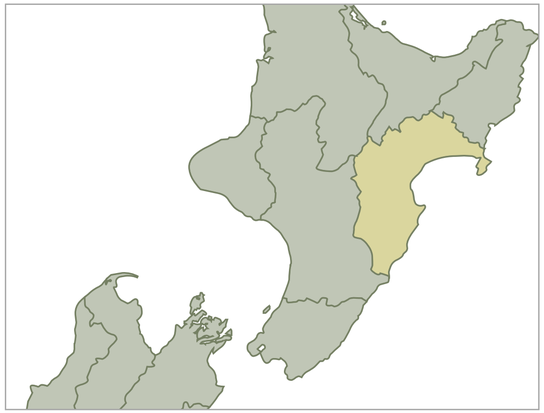
Mean temperature - Projected change in annual mean temperature between 2031-2050 and 1986-2005 (pg 38 right hand column)

Change in hot days - Projected change in average number of hot days (>25C) between 2031-2050 and 1986-2005 (pg 68, subtract present from projected)

Precipitation - Projected percentage change in annual precipitation between 2031-2050 and 1986-2005 (pg 76 right hand column. If multiple stations take average)

Extreme precipitation - Projected percentage change in depth of 1 in 50 year 1 hour extreme rainfall event (pg 100)

Drought - Qualitative statement based on projections changes in potential evapotranspiration deficit (PED) between 2031-2050 and 1986-2005 (pg 108)



Key risks of concern, in Hawke's Bay where vulnerability and exposure were rated as extreme:

Physical Risk 3: Inability for agriculture industry operators to access financial products

Physical Risk 4: Increase in pests and diseases

Physical Risk 5: Increased water stress and lack of water security

Transition Risk 1: Inability for the sector to develop a whole system approach to build resilience for effective adaptation

Transition Risk 2: Inability for the sector to keep up with the rate of global technological change

Transition Risk 5: Inability to access and maintain public acceptance to operate in key markets

Transition Risk 6: Failure to understand and meet changing consumer preferences in the market

Due to its geographical location, Hawke's Bay is largely influenced by the orography and airstreams crossing the North Island. It is a highly sunny region susceptible to highly variable and sporadic rainfall.[26]

Aligning with the sectoral scenario analysis that has been performed, we have utilised three Representative Concentration Pathways, leveraging data from MfE Climate Change Projections for New Zealand (2018) to provide detailed predictive weather analysis across the region.

Across all scenarios (left), Hawke's Bay will notably expect to see chronic increases in mean temperature (0.7 - 1.1°C) and reductions in precipitation (-1 - -2%). This can create troubling growing conditions for agriculture sector operators as the hot days and risk of drought continues to increase.

Stakeholder engagement identified that Hawke's Bay was the only region where all subsystems would be highly exposed and vulnerable to a number of the risks identified (see left) due to the climate changing to one that is drier, hotter, and with more extreme weather events across all scenarios. This includes:

- The ability for operators across the industry to access financial products, such as loans and insurance, is of increased concern as growing conditions become more difficult, with further extreme heat and precipitation impacting yields and increasing ongoing costs, reducing the financial viability of operators and land/operations values.
- Predicted significant increases in hot days (8.8 - 14.1 days) and reduced precipitation (-1 - -2%) creates increased concern on the security of water and broader water stress that will impact across operations and most notably in yields across broad acre cropping and horticulture and livestock wellbeing and quality across the dairy and beef/sheep industries.
- The monoculture nature of forestry and high international biosecurity scrutiny faced by the dairy sector, creates increased concern on the impact of an increase in pests and diseases as a result of rising mean temperatures (0.7 - 1.1 degrees).
- With agriculture contributing 9% to regional GDP[27] the region faces heightened exposure to transition risk, notably the ability for the sector nationally to develop a whole system approach that allows for sharing of resource and alignment to enable effective adaptation, which closely links to the sector's then ability to attract investment and keep up with the rate of technological change.

25 Ministry for the Environment. (2018). *Climate change projections for New Zealand.*
26 Chappell, P. R. (2013). *The climate and weather of Hawke's Bay.*
27 Ministry of Business, Innovation and Employment. (2020). *Regional fact sheet: Hawke's Bay.*

Gisborne

	RCP2.6	RCP4.5	RCP8.5
Mean temperature (°C)	0.7	0.9	1.1
Hot days (days)	8.5	11	13.6
Precipitation (%)	-1	-1	-2
	Strong drying in winter and spring		
Extreme precipitation (%)	9	12	15
Drought	Small increase	Moderate increase	Very strong increase

All information is from the following sections of MfE Climate Change Projections for New Zealand (2018):[28]

Mean temperature - Projected change in annual mean temperature between 2031-2050 and 1986-2005 (pg 38 right hand column)

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Extreme precipitation - Projected percentage change in depth of 1 in 50 year 1 hour extreme rainfall event (pg 100)

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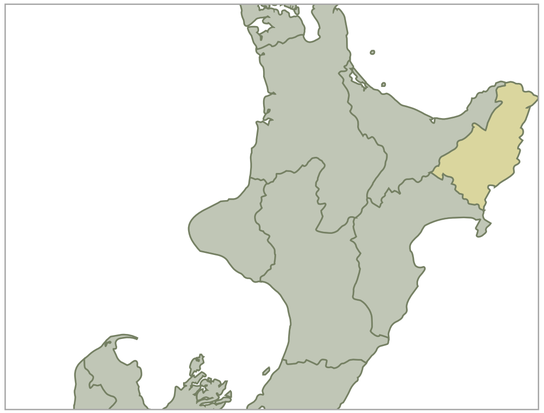

Key risks of concern, in Gisborne where vulnerability and exposure were rated as extreme:

Physical Risk 2: Increased volatility in production and reduced ability to get product to market

Physical Risk 3: Inability for agriculture industry operators to access financial products

Physical Risk 4: Increase in pests and diseases

Physical Risk 5: Increased water stress and lack of water security

Transition Risk 1: Inability for the sector to develop a whole system approach to build resilience for effective adaptation

Transition Risk 2: Inability for the sector to keep up with the rate of global technological change

Positioned as the easternmost region of New Zealand, Gisborne is a very sunny region but susceptible to highly variable and sporadic rainfall.[29]

Across all scenarios (left), Gisborne will expect to see chronic increases in average temperature (0.7 - 1.1°C) and reductions in precipitation (-1 - -2%), while also becoming more susceptible to increased extreme heat, drought and extreme precipitation (9 - 15% increases).

Gisborne already experiences a shortage of spring rainfall, prior to dramatic changes in the climate. As the climate continues to change across the region, there is increased concern on the growth and limits of agriculture activities.

Stakeholder engagement identified that Gisborne was the region facing extreme levels of exposure and vulnerability to the majority of physical risks identified (see left). The region faces a change in climate to one that is drier, hotter, and with more extreme weather events across all scenarios. As a result of the similar geographical location and sector breakdown, the risks outlined below should be considered as in addition to the risks highlighted in Hawke's Bay on the previous page.

- The high levels of physical risk coupled with increasing risks faced by the transition to a low carbon economy, creates increasing concern across numerous agriculture sub-systems in the Gisborne region. Specific risk exposure includes:
- The impact of acute weather events such as drought, hot days, extreme precipitation is of increased concern specifically in horticulture, delivering primarily to the New Zealand domestic market. Reduced precipitation (-1 - -2%) is expected to lead to increased water stress on operators and impact the viability of operations and ability to maximise yields of product.
- With agriculture contributing 10.1% or $196m[30] to regional GDP, there is significant exposure to transition risks, especially in the predominant horticulture and beef and sheep farming subsystems.

28 Ministry for the Environment. (2018). *Climate change projections for New Zealand.*
29 Chappell, P.R. (2016). *The climate and weather of Gisborne.*
30 Ministry of Business, Innovation and Employment. (2020). *Regional fact sheet: Gisborne.*

Canterbury

	RCP2.6	RCP4.5	RCP8.5
Mean temperature (°C)	0.7	0.8	1
Hot days (days)	6.2	7.5	9.5
Precipitation (%)	2.3	1.3	2
	Mixed seasonal trends. Wetter in some areas in winter and spring		
Extreme precipitation (%)	8	9	12
Drought	Moderate increase	Moderate increase	Moderate increase

All information is from the following sections of MfE Climate Change Projections for New Zealand (2018):[31]

Mean temperature - Projected change in annual mean temperature between 2031-2050 and 1986-2005 (pg 38 right hand column)

Change in hot days - Projected change in average number of hot days (>25C) between 2031-2050 and 1986-2005 (pg 68, subtract present from projected)

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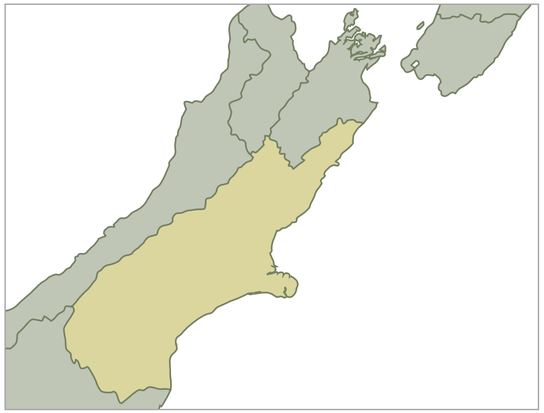
Drought - Qualitative statement based on projections changes in potential evapotranspiration deficit (PED) between 2031-2050 and 1986-2005 (pg 108)



Key risks of concern, in Canterbury where vulnerability and exposure were rated as extreme:

Physical Risk 3: Inability for agriculture industry operators to access financial products

Physical Risk 4: Increase in pests and diseases

Physical Risk 5: Increased water stress and lack of water security

Transition Risk 4: Policy becomes misaligned with the needs of the sector and how it operates

Transition Risk 5: Inability to access and maintain public acceptance to operate in key markets

Transition Risk 6: Failure to understand and meet changing consumer preferences in the market

The climate of Canterbury is dominated by the influence of the Southern Alps westerly airflows. With five main climate zones, Canterbury's climate is relatively variable with certain regions seeing higher winds and cooler, wetter weather, with others seeing lower rainfall and a relatively large annual temperature range.[32]

Across all scenarios (left), Canterbury will expect to see an increase in extreme precipitation (8 - 12%) and moderate increase in general precipitation (1.3 - 2.3%). Increases in both mean temperature (0.7 - 1°C) and extreme heat days (6.2 - 9.5) will create a moderate increase in the likelihood of drought across the region.

These physical changes have drastic consequences on agriculture operations throughout the region and will reverberate through the economy with 19.1% of national agriculture GDP coming from the region.

As New Zealand's largest and one of the highest performing agricultural regions, Canterbury produces one-fifth of the nation's agricultural GDP, employing approximately 20,000 people across the region.[33] This leaves it increasingly exposed to a variety of climate-related risks both physical and transition. Broad acre cropping, beef and sheep farming and dairy were identified by the stakeholder group as being most exposed and vulnerable to numerous transition and physical risks throughout the region. Specific risks include:

- The increased physical impacts of climate change, including drought (set to moderately increase) and extreme precipitation (set to increase 8 - 12%) will threaten the financial viability of numerous operations and increase the risk of operators being unable to access financial products. Increased difficulty of access to financial products in the region may also be driven to be increased uncertainty on land and operations values as a result of required land use changes in the upcoming years.
- With such a large contribution to national GDP and high levels of employment linked to agriculture in the region, exposure to numerous transition risks is especially high for the region, with increased concern that policy changes misaligned to the needs of the sector will have significant economic impacts on the region and related industries.
- In addition, with a wide variety of agricultural operations taking place in the region, there is increased exposure to changing consumer preferences and the requirement for the industry to be able to pivot and react effectively to maintain market share.

31 Ministry for the Environment. (2018). *Climate change projections for New Zealand.*
32 Macara, G.R. (2016). *The climate and weather of Canterbury.*
33 Ministry of Business, Innovation and Employment. (2020). *Regional fact sheet: Canterbury.*

Appendices

APPENDIX ONE: Our approach

Workshops

Kick-off Hui: 23 June 2022
The kick-off meeting involved the PwC Secretariat team, the Co-Chairs and the Leadership Group. This meeting confirmed: the project scope; working definition of the agriculture sector and subsystems; initiative objectives; programme structure; work plan; accountabilities; governance structure; and ways of working.

Risk Workshop: 8 July 2022
The Secretariat hosted and facilitated a climate-related risk identification workshop with the Technical Expert Group of the Agriculture Adaptation Roadmap workstream. This workshop identified the top physical and transition risks for the agriculture sector and its subsystems.

Scenarios Workshop: 12 August 2022
The Secretariat hosted and facilitated a climate scenarios workshop with the Technical Expert Group of the Agriculture Adaptation Roadmap workstream. This workshop developed a set of plausible climate change scenarios for the agriculture sector.

Impacts and Challenges Workshop: 9 September 2022
The Secretariat hosted and facilitated an impacts and challenges workshop with the Technical Expert Group of the Agriculture Adaptation Roadmap workstream. This workshop identified the potential impacts and challenges of climate change on the agriculture sector based on the three scenarios: **Tū-ā-pae (Orderly)** Stance in order, step in succession, **Tū-ā-hopo (Disorderly)** Misstep, **Tū-ā-tapape (Hothouse)** Faltered step, to fall.

Opportunities and Roadmap Workshops: 30 September, 7 October, and 13 October 2022
The Secretariat hosted and facilitated three climate change opportunities and roadmap workshops with all work streams of the Agriculture Adaptation Roadmap. These took place in Auckland, Wellington and Christchurch. These workshops identified the key opportunities for the agriculture sector, building on the work to establish the challenges. The opportunities were taken to agree on sector goals and objectives for the Adaptation Roadmap, landing the vision mission and key milestones, and exploring these across time horizons.

Consultation and review

Following each workshop, the co-chairs and LG were consulted on the outcomes. Feedback on the outcomes was integrated and fed into the final outputs.

Scenario development

PwC developed and utilised a comprehensive risk assessment approach, combining insights from best practice such as the Task Force on Climate-Related Financial Disclosures and the ISO14090:2019 - Adaptation to climate change standards, to develop a tailored and fit for purpose approach for this unique piece of work.

Our approach allowed us to create a comprehensive understanding of the most material climate related risks and the top drivers of change that influence the sector before building the scenarios. This enhanced our understanding of how the risks then impacted the sector and the challenges that may present.

The steps taken were as follows:

1. **Identification of the most significant climate-related risks:** The top physical and transition risks were determined through discussions with the TEG and subsequently agreed with the LG and Co-chairs.
2. **Development of a risk and scenario analysis model:** The most significant physical risks and most significant transition risks were voted on and agreed to by the governance groups. These 11 top risks were then used to create a 'scenario structure', whereby the range of scenarios covered the range of possible manifestations of each top risk. To ensure comparability and consistency with XRB requirements, we then reconciled these axes with the scenario framework set out by the Network for Greening the Financial System (NGFS)[34]. Establishing this framework allowed us to develop climate scenarios that capture a broad range of plausible outcomes for the sector.
3. **Identification of key drivers of change and development of scenario narratives:** With an understanding of the climate-related risks facing the agriculture sector and scenario characteristics established, we worked with the TEG to identify the top drivers of change that influence the sector. Drivers of change are broad-scale factors that influence the sector and often create risks and opportunities. Once the key drivers of change were identified, they were then used to develop scenario narratives that reflect critical influences on the sector. We then built out the scenario narratives using information from global and national reference scenarios and climate data. Reference scenario information was taken from scenarios developed by the NGFS, the Climate Change Commission and the International Energy Agency, and information included in Shared Socioeconomic Pathways and reported by the Intergovernmental Panel on Climate Change. We also used climate data from the National Institute for Water and Atmospheric Research.

Key elements of the project

Risk assessment

The most significant physical and transition risks for New Zealand's agriculture sector were identified. These were used to create the scenario framework.

Scenario analysis

Three climate scenarios were explored. Twelve drivers of change and how they manifest under each of the three scenarios created the basis for the development of scenario narratives. The narratives build a picture of what the world may look like under each scenario.

Impact, consequences and challenges

The challenges experienced by industry participants were collated and articulated, including the impact of doing nothing about climate change.

Opportunities

We evaluated the opportunities that the changing climate may bring to the agriculture sector, including an opportunity to build in regenerative thinking.

Adaptation roadmap

We collectively agreed pragmatic and tangible adaptation actions that support the sector to transition with the effects of climate change and allow the sector to make confident and coordinated decisions.

34 Network for Greening the Financial System. (2020). *Technical document: Guide to climate scenario analysis for central banks and supervisors.* NGFS.

APPENDIX TWO: Scenario characteristics

Paragraph 51 of NZ CS3 outlines the methodologies and assumptions that organisations must disclose as part of their requirements under the Climate-related Disclosures regime. A critical requirement is “a description of the various emissions reduction pathways in each scenario and the assumptions underlying pathway development over time, including the scope of operations covered, policy and socioeconomic assumptions, macroeconomic trends, energy pathways, carbon sequestration from afforestation and nature-based solutions and technology assumptions including negative emissions technology;”.

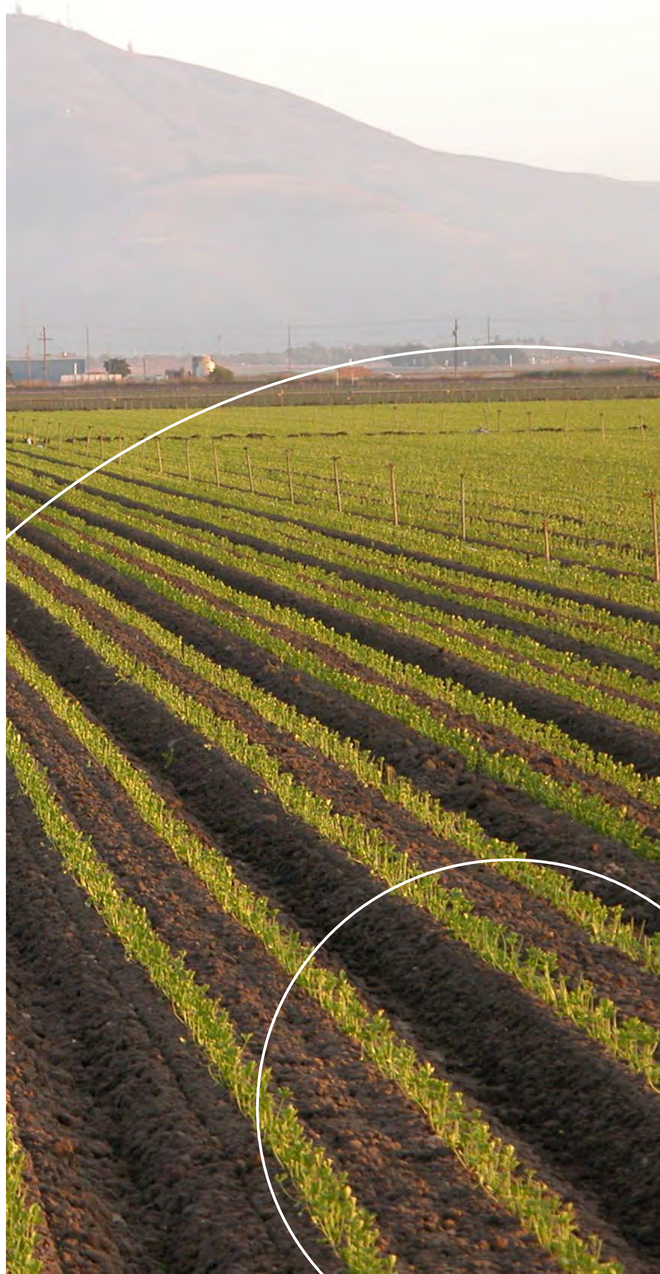
The table below sets out the key background assumptions in each sector based on the NGFS, SSP, IEA and CCC scenarios.

	Tū-ā-pae (Orderly)	Tū-ā-hopo (Disorderly)	Tū-ā-tapape (Hothouse)
Energy	Energy supply is mostly decarbonised, with 98% of electricity from renewable sources, and 89% of total energy from renewable sources.	Since 2030, there has been a rapid shift to low emissions energy, but there is still a way to go. 76% of total energy consumed is renewable.	Energy remains reliant on high-emitting fuels. Renewable sources provide 46% of total consumed energy.
Transport	Since 2032, all new light vehicles entering NZ have been electric, and integrated transport systems, including walking, cycling and public transport are common in urban areas.	After a delay, all new light vehicles have been electric since 2040, but private car ownership has declined. Buses and trains are decarbonising quickly.	There are still ICE vehicles entering the country in 2050. Roads have been upgraded to accommodate more vehicles and public transport is not prioritised.
Buildings	Building standards have been implemented that mandate the use of sustainable materials and construction methods. New buildings must be carbon-neutral and old buildings have been retro-fitted with efficient heating and cooling systems.	Sustainable building standards were introduced in the 2030s.The costs of retrofitting existing buildings remains high, so only buildings new since 2035 are fitted out with low emissions in mind.	Building standards prioritise resilience to physical impacts rather than sustainability. Coal and gas boilers remain common and construction waste is high.
Land use	Large areas of land have been protected to reverse ecosystem decline. Iwi/Māori have a strong voice in what happens to the land in their local area.	There is no national strategy for land use. Since 2030, some areas have been rewilded as unsustainable farms have gone out of business.	Land use continues to go to those who can derive the greatest profits from it. Urban sprawl ensues and livestock agriculture remains widespread.
Afforestation and carbon sequestration	There is widespread use of carbon capture and storage (CCS) globally, though only a few cases in New Zealand. Pine and native forestry grows strongly, with biodiversity protection a key criteria for approval of new forests.	Focus on emissions reductions leads to large areas of pine monocultures. Rushed and costly global push for more CCS tech, though not really seen in NZ.	Little use of CCS globally. Pines continue to be planted for timber, but native forestry is not incentivised.

Scenario short, medium and long term indicators

Paragraph 10 of NZ CS1 requires reporting entities to provide "a description of the climate-related risks and opportunities it has identified over the short, medium, and long term". To enable this, we have provided key indicators and high level descriptors of each scenario across the short (2023-2025), medium (2026-2035) and long (2036-2050) term. Note that entities are also required to describe "how it defines short, medium and long term and how the definitions are linked to its strategic planning horizons and capital deployment plans" (Paragraph 14(a)). This means that reporting entities will need to assess the relevance of these time horizons for their business and, if other time horizons are more suitable, adjust them.

Tū-ā-pae (Orderly)	Short (2025)	Medium (2035)	Long (2050)
Physical climate			
Global temperature rise relative to preindustrial (°C)	1.4	1.5	1.6
Sea level rise relative to 2005 (m)	0.09	0.13	0.2
Socio-economic indicators			
Global emissions ($GtCO_2e$)	49	40	26
NZ population increase relative to 2020 (%)	3%	9%	16%
NZ carbon price ($NZD/tonne)	107	186	277
NZ net emissions ($MtCO_2e$)	65	35	6
High level descriptors			
	Physical climate is similar to today, with increasing flooding and fire weather events. Emissions pricing is beginning to cause changes to the NZ economy. Government direction on climate is clear - an inclusive and fast transition. Agricultural practices are similar to today, but social push to reduce livestock products is growing.	Climate impacts have worsened but not too rapidly. Government has introduced a National Food Strategy and strategic land use plan for the country. The shift towards a diverse sector with significantly more plant-based has gained strong momentum and is moving fast. Horticulture and cropping has grown. Technology is advancing rapidly in sustainable agriculture and shipping, and capital is accessible for these organisations.	The country and globe have transitioned to a low emissions economy. Entire sectors or large parts of sectors have disappeared or transitioned into more sustainable industries. The New Zealand agriculture sector has become innovative and diverse with a much smaller contribution from livestock. Climate adaptation means communities and businesses are resilient to physical impacts.



Scenario short, medium and long term indicators

Tū-ā-hopo (Disorderly)	Short (2025)	Medium (2035)	Long (2050)
Physical climate			
Global temperature rise relative to preindustrial (°C)	1.4	1.7	2
Sea level rise relative to 2005 (m)	0.09	0.14	0.22
Socio-economic indicators			
Global emissions ($GtCO_2e$)	55	58	57
NZ population increase relative to 2020 (%)	4%	12%	22%
NZ carbon price ($NZD/tonne)	107	259	369
NZ net emissions ($MtCO_2e$)	67	49	24
High level descriptors			
	Physical climate is similar to today, with increasing flooding and fire weather events. There is still no concerted government effort to reduce emissions, but a very strong social push. Emissions prices remain relatively low.	Climate impacts have worsened with a number of compound weather events wreaking havoc on the sector. Focus has rapidly shifted to mitigation and a number of policies have been introduced. Emissions prices have risen fast. Globally, there is a strong focus on reducing emissions, leading to a rapid increase in forestry and decrease in livestock products. Organisations are suffering from the shock of the sudden shift in Government priorities. Capital and insurance are suddenly hard to access for polluting organisations.	The world still has some way to go to get to net zero emissions and stabilise warming, but a lot of the work has been done. The disruptive transition pushed a lot of organisations out of business, including many parts of the agriculture sector who focussed too much on intensive or high-emitting livestock. Costs have risen due to a high emissions price and restrictive trade rules, and there is a lack of Government support for the sector.

Tū-ā-tapape (Hothouse)	Short (2025)	Medium (2035)	Long (2050)
Physical climate			
Global temperature rise relative to preindustrial (°C)	1.4	1.8	2.5
Sea level rise relative to 2005 (m)	0.09	0.15	0.32
Socio-economic indicators			
Global emissions ($GtCO_2e$)	65	79	103
NZ population increase relative to 2020 (%)	5%	14%	26%
NZ carbon price ($NZD/tonne)	35	35	35
NZ net emissions ($MtCO_2e$)	69	60	40
High level descriptors			
	Physical climate is similar to today, with increasing flooding and fire weather events. There is still no concerted government effort to reduce emissions, but a very strong social push. Emissions prices remain relatively low.	The physical impacts of climate change are beginning to wreak havoc across the country, frequently interrupting farm systems and supply chains. Some regions and farm systems have become unviable due to physical climate change. Food supply and food security have been prioritised over sustainability, so there is still a market for NZ livestock products, though the costs have risen significantly.	Climate impacts devastate communities, farm systems and supply chains. The toll on physical and mental health is high. Focus has shifted to strategic adaptation to the physical impacts of climate change, and local governments are empowered to adapt, but action has not been fast enough. Capital and insurance has become very difficult or impossible to access in some regions.

APPENDIX THREE: Detailed climate scenario data

Tū-ā-pae scenario - Orderly

Physical climate change		
Variable/indicator	**2031-2050 value relative to 1986-2005 (unless otherwise stated)**	**Source**
Temperature change above pre-industrial global in 2050	1.6°C	RCP 2.6 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Annual mean temperature change NZ	0.7°C	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme rainfall (percentage change in depth of 1 in 100 year 1 hour rainfall event)	15%	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme heat (change in days over 25°C)	15 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Snowfall (change in snowfall days)	-10 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Glacier retreat (mass in 2050 relative to 2000)	0.68	Anderson, B., Mackintosh, A.N., Dadić, R., Oerlemans, J., Zammit, C., Doughty, A., Sood, A., & Mullan, B. (2021). Modelled response of debris-covered and lake-calving glaciers to climate change, Kā Tiritiri o te Moana/Southern Alps, New Zealand. Global and Planetary Change, 205, 103593.
Sea level rise 2005-2050	0.2m	Ministry for the Environment. (2022). Interim guidance on the use of new sea-level rise projections. https://environment.govt.nz/publications/interim-guidance-on-the-use-of-new-sea-level-rise-projections/

Global economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
Global emissions (CO_2-e)	26 Gt	SSP-1 RCP 2.6 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global oil price (2020 NZD/tonne)	$43	International Energy Agency. (2022). Global energy and climate model. IEA. https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze
Global population (mn)	8410	SSP-1 RCP 2.6 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global GDP (2020 NZD tn)	$629	SSP-1 RCP 2.6 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10

Tū-ā-pae scenario - Orderly

NZ policy, economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
NZ net emissions (CO_2e)	5936 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ gross emissions (CO_2e)	26287 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Electricity from renewable sources (%)	98%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ carbon price (2022 NZD/tonne)	$277	New Zealand Treasury. (2021). CBAx tool user guidance. Central pathway. https://www.treasury.govt.nz/publications/guide/cbax-tool-user-guidance
NZ population (m)	5913	Stats NZ. National population projections: 2022(base)–2073. https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/
EV light passenger vkt (%)	98%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
EV bus vkt (%)	94%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Dairy herd change 2020-2050	-30%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Livestock herd change 2020-2050	-22%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Horticulture and arable land change 2020-2050	34%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area change 2020-2050	30%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area change 2020-2050	704%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area (Mha)	2.45	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area (Mha)	0.77	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Tailwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx

Tū-ā-hopo scenario - Disorderly

Physical climate change		
Variable/indicator	**2031-2050 value relative to 1986-2005 (unless otherwise stated)**	**Source**
Temperature change above pre-industrial global in 2050	2°C	RCP 4.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Annual mean temperature change NZ	0.8°C	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme rainfall (percentage change in depth of 1 in 100 year 1 hour rainfall event)	18%	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme heat (change in days over 25°C)	20 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Snowfall (change in snowfall days)	-15 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Glacier retreat (mass in 2050 relative to 2000)	0.63	Anderson, B., Mackintosh, A.N., Dadić, R., Oerlemans, J., Zammit, C., Doughty, A., Sood, A., & Mullan, B. (2021). Modelled response of debris-covered and lake-calving glaciers to climate change, Kā Tiritiri o te Moana/Southern Alps, New Zealand. Global and Planetary Change, 205, 103593.
Sea level rise 2005-2050	0.22m	Ministry for the Environment. (2022). Interim guidance on the use of new sea-level rise projections. https://environment.govt.nz/publications/interim-guidance-on-the-use-of-new-sea-level-rise-projections/

Global economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
Global emissions (CO_2-e)	57 Gt	SSP-2 RCP 4.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global oil price (2020 NZD/tonne)	$89	International Energy Agency. (2022). Global energy and climate model. IEA. https://www.iea.org/reports/world-energy-model/sustainable-development-scenario-sds
Global population (mn)	9189	SSP-2 RCP 4.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global GDP (2020 NZD tn)	$543	SSP-2 RCP 4.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10

Tū-ā-hopo scenario - Disorderly

NZ policy, economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
NZ net emissions (CO_2e)	23956 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ gross emissions (CO_2e)	45658 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Electricity from renewable sources (%)	96%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ carbon price (2022 NZD/tonne)	$369	New Zealand Treasury. (2021). CBAx tool user guidance. High pathway.https://www.treasury.govt.nz/publications/guide/cbax-tool-user-guidance
NZ population (m)	6156	Stats NZ. National population projections: 2022(base)–2073. https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/
EV light passenger vkt (%)	92%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
EV bus vkt (%)	87%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Dairy herd change 2020-2050	-17%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Livestock herd change 2020-2050	-19%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Horticulture and arable land change 2020-2050	1%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area change 2020-2050	40%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area change 2020-2050	459%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area (Mha)	2.64	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area (Mha)	0.53	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Headwinds. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx

Tū-ā-tapape scenario - Hothouse

Physical climate change		
Variable/indicator	**2031-2050 value relative to 1986-2005 (unless otherwise stated)**	**Source**
Temperature change above pre-industrial global in 2050	2.5°C	RCP 8.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Annual mean temperature change NZ	1°C	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme rainfall (percentage change in depth of 1 in 100 year 1 hour rainfall event)	22%	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Extreme heat (change in days over 25°C)	30 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Snowfall (change in snowfall days)	-20 days	Ministry for the Environment. (2018). Climate change projections for New Zealand. https://environment.govt.nz/publications/climate-change-projections-for-new-zealand/
Glacier retreat (mass in 2050 relative to 2000)	0.62	Anderson, B., Mackintosh, A.N., Dadić, R., Oerlemans, J., Zammit, C., Doughty, A., Sood, A., & Mullan, B. (2021). Modelled response of debris-covered and lake-calving glaciers to climate change, Kā Tiritiri o te Moana/Southern Alps, New Zealand. Global and Planetary Change, 205, 103593.
Sea level rise 2005-2050	0.32m	Ministry for the Environment. (2022). Interim guidance on the use of new sea-level rise projections. https://environment.govt.nz/publications/interim-guidance-on-the-use-of-new-sea-level-rise-projections/

Global economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
Global emissions (CO_2-e)	103 Gt	SSP-5 RCP 8.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global oil price (2020 NZD/tonne)	$157	International Energy Agency. (2022). Global energy and climate model. IEA. https://www.iea.org/reports/world-energy-model/announced-pledges-scenario-aps
Global population (mn)	8509	SSP-5 RCP 8.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10
Global GDP (2020 NZD tn)	$754	SSP-5 RCP 8.5 from SSP Database (Shared Socioeconomic Pathways) Scenario Explorer. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10

Tū-ā-tapape scenario - Hothouse

NZ policy, economic and social		
Variable/indicator	**2050 value (unless otherwise stated)**	**Source**
NZ net emissions (CO_2e)	39643 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ gross emissions (CO_2e)	63054 kt	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Electricity from renewable sources (%)	92%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ carbon price (2021 NZD/tonne)	$35	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
NZ population (m)	6406	Stats NZ. National population projections: 2022(base)–2073. https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/
EV light passenger vkt (%)	80%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
EV bus vkt (%)	83%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Dairy herd change 2020-2050	-13%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Livestock herd change 2020-2050	-15%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Horticulture and arable land change 2020-2050	1%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area change 2020-2050	48%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area change 2020-2050	134%	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Exotic forestry land area (Mha)	2.8	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx
Native forestry land area (Mha)	0.22	He Pou a Rangi, Climate Change Commission. (2021). Scenarios dataset for the Commission's 2021 Final Advice (output from ENZ model). Current Policy Reference. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-lowemissions-future-for-Aotearoa/Modelling-files/Scenarios-dataset-2021-final-advice.xlsx

APPENDIX FOUR: Use of reference scenarios

The scenarios presented in this report are the product of a collaborative effort bringing together experts across the sector. However, establishing the high level boundary conditions for the scenarios often required selecting information from the range of existing climate scenario frameworks. This process involves attempting to reconcile often disparate and inconsistent pieces of information from different scenarios. This section will outline the reference scenarios used in this report and the rationale behind those choices.

Network for Greening the Financial System (NGFS)

The NGFS framework has become a common tool for determining high level scenario narratives. It was decided that the 'Orderly', 'Disorderly' and 'Hothouse' scenarios best spanned the range of plausible futures for the agriculture sector. 'Orderly (Net Zero 2050)" describes a world with a smooth transition to net zero carbon dioxide emissions, 'Disorderly (Delayed Transition)' describes a world with little change until 2030, before a disruptive and rapid reduction in emissions, and 'Hothouse (Current Policies)' describes a world with continuing high emissions.

Representative Concentration Pathways (RCPs)

RCPs describe emissions of greenhouse gases into the future and associated climate impacts. These were used to determine the physical climate characteristics of each scenario. This report uses four RCPs: RCP1.9, 2.6, 4.5 and 8.5. The numbers relate to the heating effect of emissions on the climate. That is, the higher the RCP, the higher emissions are and the more warming the world experiences.

Scenario	RCP used	Rationale
Orderly Tū-ā-pae	RCP1.9 RCP2.6	RCP1.9 is the most stringent mitigation scenario in which carbon dioxide emissions decline to net zero relatively quickly. It reflects a world in which warming is limited to around 1.5°C. Unfortunately there is no downscaled climate data for New Zealand for RCP1.9, so RCP2.6 was used. RCP2.6 is also a stringent mitigation scenario in which warming is limited to around 1.7°C, so the physical impacts of climate change are likely to be similar.
Disorderly Tū-ā-hopo	RCP4.5	RCP4.5 sees global emissions peak around 2040 and slowly begin to decline thereafter. The climate impacts of this are similar to what we would expect in the disorderly scenario described in this report.
Hothouse Tū-ā-tapape	RCP8.5	RCP8.5 is a scenario in which emissions continue to rise, leading to severe physical impacts. There is some controversy around the use of RCP8.5 given its very high emissions. However, although the emissions trajectory in RCP8.5 may be becoming less plausible, the climate impacts of that emissions trajectory are possible even under a lower emissions scenario. It was therefore decided to use RCP8.5 for the Tū-ā-tapape scenario.

These RCPs have been downscaled to the New Zealand context by NIWA. The New Zealand-specific climate impacts in these scenarios were taken from the downscaled NIWA data. The RCPs have also been linked to the Shared Socioeconomic Pathways (SSPs; see below) in recent years.

Shared Socioeconomic Pathways (SSPs)

SSPs were developed to examine how global society, demographics and economics might change over the next century (Carbon Brief, 2018). The SSPs are useful for linking local or sector-specific trends to a global context. The choices made in this scenario set are consistent with the examples used in the XRB guidance.

Scenario	SSP used	Rationale
Orderly Tū-ā-pae	SSP1	SSP1: Sustainability reflects a world in which ecological and human wellbeing is prioritised. There are 'low challenges to mitigation and adaptation'. This aligned well with the smooth transition described in Tū-ā-pae.
Disorderly Tū-ā-hopo	SSP2	SSP2: Middle of the Road describes a world with largely similar social, economic and technological trends to today. There are 'medium challenges to mitigation and adaptation'. This aligns well with the lack of action until 2030 before a dramatic change after that.
Hothouse Tū-ā-tapape	SSP5	SSP5: Fossil-fueled development reflects a world in which economic growth is prioritised above progress on environmental issues, creating a world primed for transformative adaptation. There are 'high challenges to mitigation and low challenges to adaptation'.

He pou a rangi Climate Change Commission (CCC)

As part ofInāia tonu nei: a low emissions future for Aotearoa, the Climate Change Commission's advice to Central Government on the first three emissions budgets, the CCC published a set of pathways that outlined potential changes in land use, energy, transport and other economic indicators over the coming decades. Some of these pathways, including *Headwinds* and *Tailwinds*, reflect pathways that meet the emissions targets in the Climate Change Response Act. In the *Headwinds* pathway, technology uptake and behaviour change is relatively slow compared to *Tailwinds*, which has fast technology uptake and behaviour change. Some information from these two pathways was chosen for inclusion in the Tū-ā-hopo and Tū-ā-pae scenarios, respectively.

The CCC also published data from a *Current Policy Reference* scenario, in which policy remains weak. This was chosen for use in the Tū-ā-tapape scenario.

Shared Policy Assumptions for New Zealand (SPANZ)

Frame et al. (2018)[35] sets out a framework for downscaling global SSPs to the New Zealand context. These scenarios provide a set of shared policy assumptions (SPAs)for New Zealand, which explore New Zealand's consistency with global policy trends, and outline some high level themes of national policy. Only small pieces of information were used from the SPAs in these scenarios.

Scenario	SPANZ used	Rationale
Orderly Tū-ā-pae	SPANZ F	In SPANZ F, adaptation and mitigation are prioritised and New Zealand leads global innovation in some areas. There is a strong moral push to lead the global transition.
Disorderly Tū-ā-hopo	SPANZ B	In SPANZ B, adaptation tends to be incremental and focused on short term gains. There is little long term vision associated with adaptation or mitigation.
Hothouse Tū-ā-tapape	SPANZ D	In SPANZ D, adaptation is strategic and at times transformative, but there is little attempt to meaningfully mitigate.

35 Frame et al. (2018). Adapting global shared socio-economic pathways for national and local scenarios. *Climate Risk Management.*

APPENDIX FIVE: Acknowledgements

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- Craig Ellison - Ngāi Tahu Holdings

Leadership Group

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- David Chin - Livestock Improvement Corporation (LIC)
- Charlotte Rutherford - Fonterra
- Kate Beddoe - Silver Fern Farms
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- Kerensa Johnston - Wakatū Incorporation
- Rachel Depree - Zespri
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- Dr Fiona Carswell - Manaaki Whenua - Landcare Research
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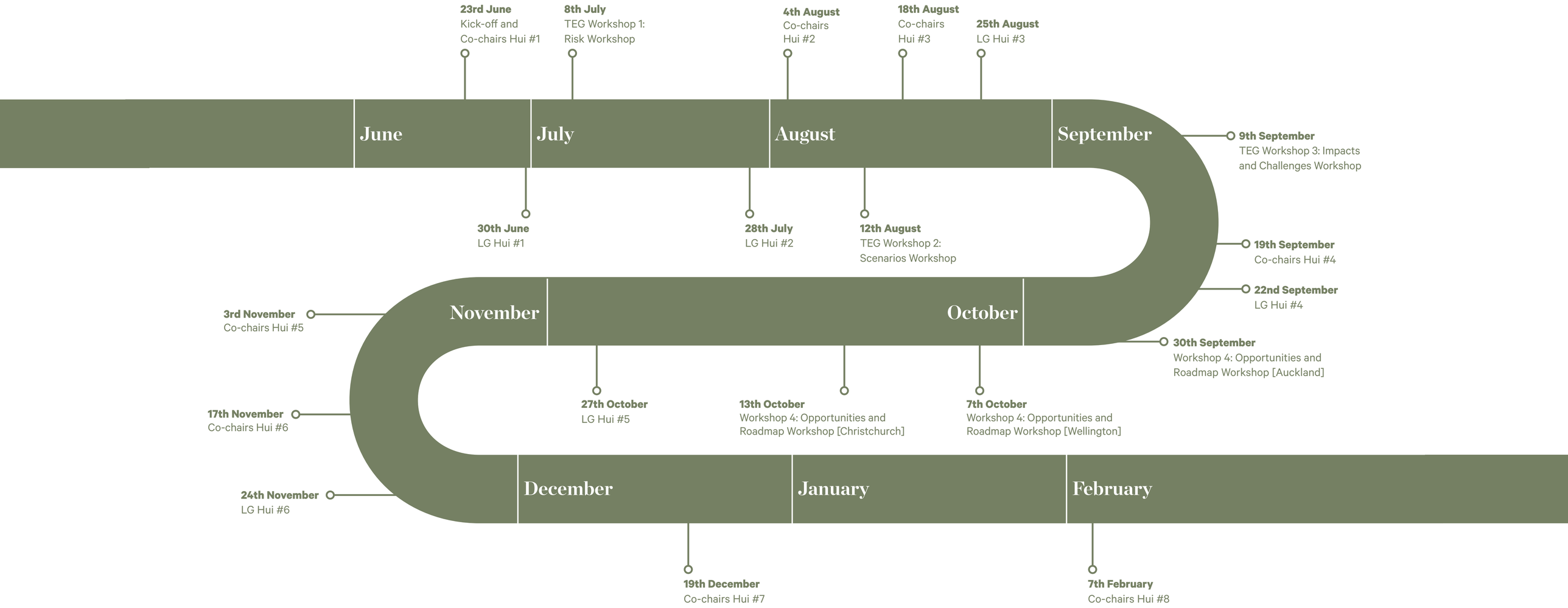
- Annabell Chartres
- Dr Victoria Hatton
- Dominic Thorn
- Ethan Kay
- Phoebe McCartie
- Electra Scott
- Jade Collins

APPENDIX SIX: Project timeline



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