CAN INCREMENTAL CHANGE SUPPORT SYSTEM-LEVEL ADAPTATION?

National Science Challenges

THE DEEP SOUTH

Te Kōmata o Te Tonga

A report on the Adapting Aotearoa: Towards A Climate Resilient Land and Food System symposium brought to you by the Deep South National Science Challenge in collaboration with Resilience to Nature's Challenges and Our Land and Water National Science Challenges.

Changing with our climate

START ADAPTATION PLANNING TODAY

ACKNOWLEDGEMENTS

DEDICATION

This report is dedicated to the memory of climate advocate and journalist Rod Oram. Rod sadly passed away a few months after his challenging and through-provoking talk at Adapting Aotearoa. Rest in peace, Rod, and thank you for your relentless efforts to champion the facts about climate change.

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ISBN:

PUBLICATION DATE: 03/2024

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CONTENTS

EXECUTIVE SUMMARY

He kai kei aku ringa

There is food at the end of my hands

This whakatauki speaks to resilience, empowerment, and hope. It refers to the ability to have and use the necessary skills, knowledge, and resources to be resilient and thrive. It is how we hope New Zealand's primary sector will rise to the challenge of climate adaptation.

As a country, New Zealanders are experienced in adapting to natural hazards and sudden changes in the weather. However, our resilience levels for adapting to climate change are constantly being tested.

Adaptation is an inescapable journey that we are only just beginning to understand in a practical way. As an island nation, we are at risk of cascading and compounding effects of the coming change in temperature. Our land and food systems are most at risk, but we know that our infrastructure and supply chains will also experience broader impacts.

The success of Adapting Aotearoa was in bringing together farmers and researchers to decrease the dissonance between their two different frames of understanding around climate adaptation. These frames can be expressed as:

- Farmers feel as though researchers are demanding wholesale transformative change without understanding economic reality or appreciating the incremental adjustments that farmers make.
- Scientists feel as though farmers do not understand the severity of possible scenarios and therefore are not acting with the appropriate urgency or willingness to examine system change.

We need to bridge the gap between farmers' understanding of incremental change and response and the need for research-informed transformation. Science has shown that there is no way adapt to the changing climate without cost – someone has to lose something. If difficult decisions are not made now by farmers, then the choice will be made for farmers by insurance companies, banks, local and central government, supply chain operators, or shifts in export requirements. Any choice not to act will disproportionately negatively affect rural communities.

Research has shown us three future scenarios for the agricultural sector in Aotearoa New Zealand. The choice of which path we follow is up to farmers.

While climate change is a global issue, the solutions are increasingly local. We need strong, informed, resourced, and empowered rural communities. To get there we need to continue to discuss across the discomfort and dissonance of different viewpoints and reach a practical approach that supports successful adaptation:

- Researchers need to work to understand commercial realities and provide information at an appropriately local scale.
- Farmers need to use their adaptability and practical experience to consider a more ambitious approach to sector change.

"Society needs to realise that the impacts of climate change will be significant and that small incremental changes might help, but they are not enough. I think society needs to realise that transformation is necessary and that this will require personal and societal sacrifices to be made. We can't just keep tweaking business as usual. It will require strong leadership from government without over regulation, backed up by funding and resourcing."

Feedback questionnaire

"Agreement on aspirational solutions is easy, the hard part is implementing. Need to think about how to scale back from aspirational to the pragmatic, and in pragmatic steps. Also, the challenge of how to build adaptation into BAU [business as usual] and get ahead of daily urgent priorities for the land and food system."

Feedback questionnaire

INTRODUCTION

There is widespread understanding that changes to the climate are happening and that we must adapt. The primary sector is ripe with solutions to climate issues and innovative responses to our warming planet. It is accustomed to responding to natural hazards and experienced in responding to changing conditions.

As managers, owners, and users of the land, the primary sector is accustomed to changing with the weather. A farmer's work is never static and a successful farmer responds to what is in front of them with careful forethought and an eye for their land's sustainable environmental and economic future.

"Farmers know what is best to grow, where and when, and the impact of climate."

Symposium participant.

There is an inherent tension between science and the practical implementation. We know the scope and scale of adaptation to climate change can seem daunting.

"[there is a] huge disconnect between [the] rural sector, who feel prepared and like they are already adapting, and the research sector which is seeing a more troubling future that they consider no one is prepared for."

Feedback questionnaire

Farmers feel as though researchers are asking for wholesale transformative change without understanding economic reality or appreciating the incremental adjustments that farmers make.

Scientists feel as though farmers do not understand the severity of possible scenarios and therefore are not acting with the appropriate urgency or willingness to examine system change.

Recently produced future primary sector scenarios (see page 9) portray a wide range of possible futures, depending on the approach taken nationally and internationally:

» **Ambitious transition:** Change characterised by innovation, nature-based solutions, and transformative

practices, and a drive for a fair, equitable approach. Physical risks are better managed, and biodiversity is enhanced.

- **Reality bites:** Physical impacts increase, with many whānau and communities displaced by extreme weather. Recovery and costs put pressure on government services. Innovation is driven by incremental policy changes, disrupted distribution networks, and higher input costs.
- **Abandoned ambitions:** High risk of severe droughts, mass migration, global food shortages, and supply chain volatility. Biodiversity depletion and climate anxiety are rampant, and government is under strain and in near constant reactive mode.

At present, researchers believe the agricultural sector is heading for the reality bites scenario, while farmers think they have an ambitious transition in hand.

While these scenarios are nationally focused, outcomes can also be affected at a local level through the choices of individual farmers and primary sector organisations. More information about the local impacts of these scenarios is required so farmers can make better actionable decisions.

Some elements were universal across the symposium, with the primary sector, iwi and hapū, local communities, government, or researchers all in agreement that while climate change is a global issue, the solutions are increasingly local. There was a clear call for strong communities with engagement resulting in a common purpose, education that creates a common understanding of research and its implications, and funding that allows for collective inter and intra community support.

"We've used indigenous knowledge and world view to create local connected clusters of communities. We've fostered a network with other district neighbours so we can each tap into resilience of others when necessary. We've used learnings from previous 'disasters' to change systems to be more locally focused."

Symposium participant

We need farmers and researchers to work together to make sure the ways we adapt are planned in advance, well-informed, and adaptable enough within themselves that they won't lead to unintended consequences over time. The risk of maladaptation and the need to balance uncertainty requires both physical infrastructure and planning processes that support adaptive change. Such infrastructure needs an eye for planning over decades that can be implemented in the space of years.

We can better understand limits, trade-offs, and unintended consequences by forging connections, like those we make at gatherings like this one, and by considering long term futures.

Adapting Aotearoa posited a future where farmers thrive, and the primary sector is supported to transform to best survive the changing climate. To achieve this future, we need to bring farmers and researchers together to find a practical approach that supports successful adaptation. This symposium follows related rolling symposiums held by the Deep South Challenge: Growing Kai Under Increasing Dry and Ko Papa Ko Rangi: reframing the costs of climate change.

ESSENTIAL, EXTRAORDINARY, EXISTENTIAL

A panel at the symposium was titled "Transformational change – Possible, Plausible, Preferable?" Rod Oram's challenge to the primary sector was to rephrase this as "Transformational change – Essential, Extraordinary, Existential." Adapting to climate change is:

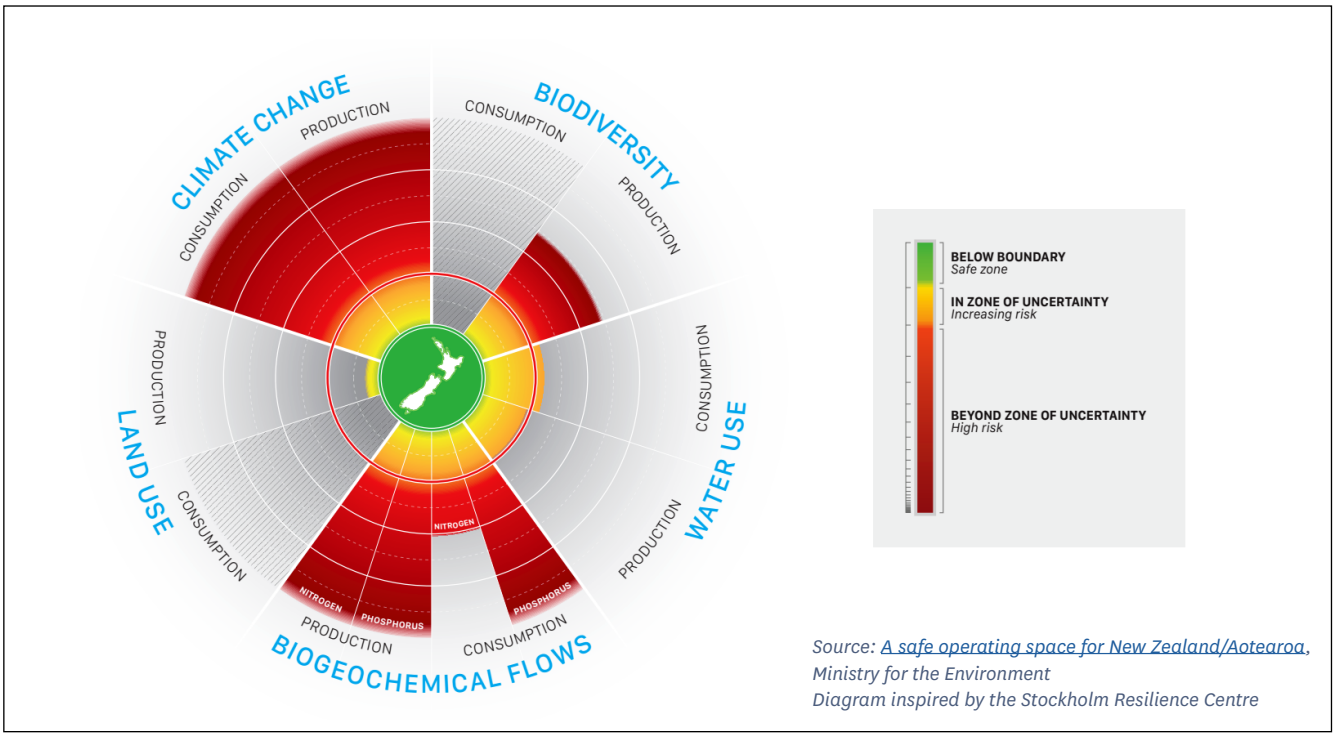
- **Essential:** if the agricultural sector wishes to survive and thrive adaptation is imperative.
- **Extraordinary:** the transition to a future where the agricultural sector thrives in the face of a changing climate will require unprecedented, innovative, and remarkable work that builds on current success.
- **Existential:** each farmer is responsible for their own actions, and must act to affirm the agricultural sector's continued existence and value.

To better explain why transformational change is essential, Figure 1 shows where New Zealand is breaking five planetary boundaries. New Zealand exceeds its "fair share" of the global safe operating space for most production-based (territorial) and consumption-based boundaries.

Extraordinary change is also possible. The agricultural sector already puts the land at the heart of everything it does. Figure 2 gives a Māori perspective of the iconic doughnut economic model reimagined by Teina Boasa-Dean and Juhi Shareef. This indigenous reimagining puts the ecological foundation at the centre, denoting that it is Ranginui (the sky, the father of all things) and Papatūānuku (the earth, the mother of all things) that together enable humanity to thrive.

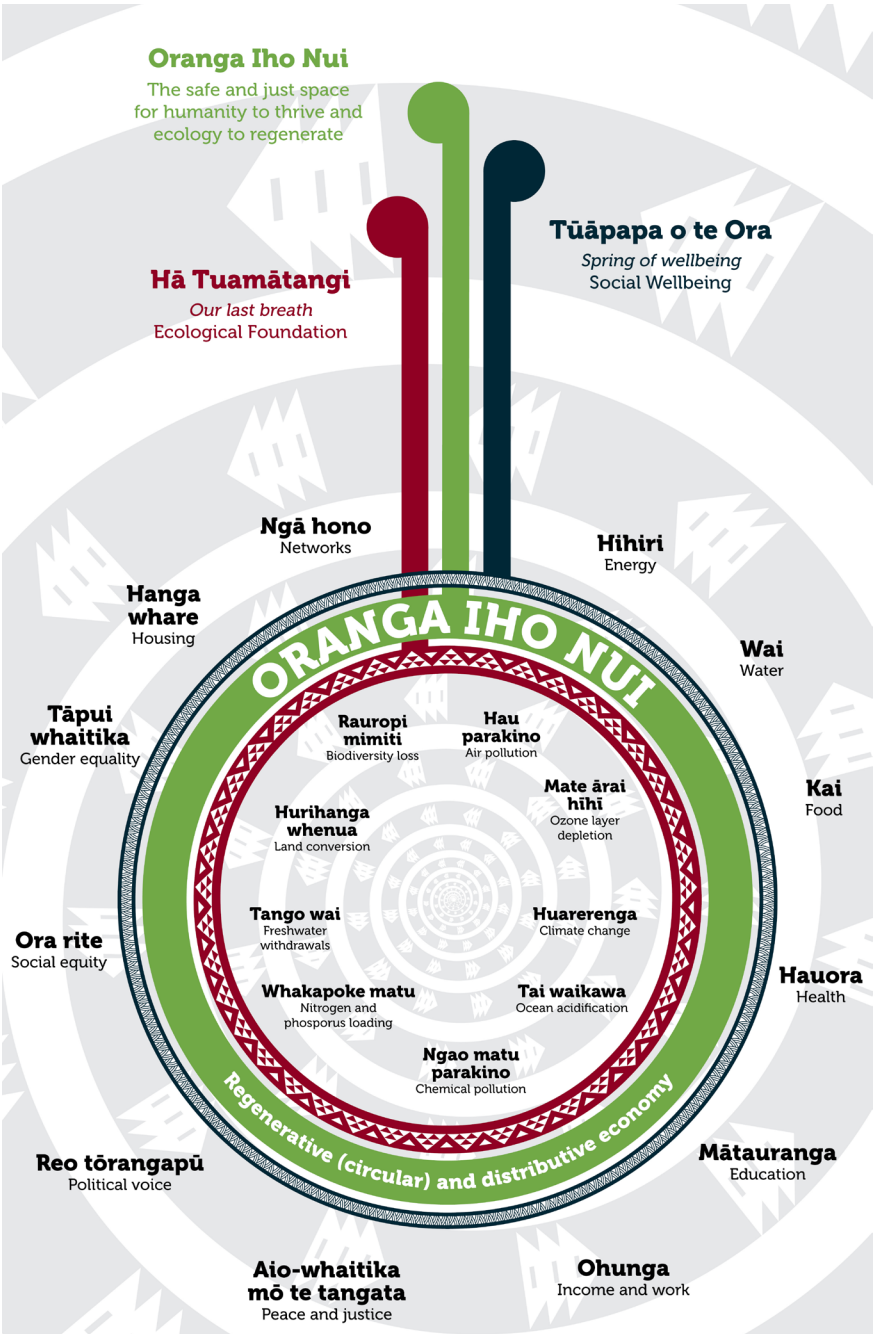
One of the central tenets of existentialism is that personal freedom, individual responsibility, and deliberate choice are essential to live well. Rod's final point of transformational change as 'existential' encapsulates the push for urgent transformative change in response to the pace and magnitude of climate change. It also clarifies that the research sector must work with farmers, who are not only experts in adapting to the immediate conditions and situations in which they find themselves but are the only people capable of actioning needed change.

FIGURE 1: FIVE PLANETARY BOUNDARIES TRANSLATED TO AOTEAROA NEW ZEALAND



Source: A safe operating space for New Zealand/Aotearoa, Ministry for the Environment
Diagram inspired by the Stockholm Resilience Centre

FIGURE 2: A REIMAGINING OF KATE RAWORTH'S DOUGHNUT ECONOMICS FROM A TŪHOE MĀORI PERSPECTIVE



A Māori perspective of the iconic doughnut economic model, reimagined by Teina Boasa-Dean and Juhi Shareef. This indigenous reimagining puts the ecological foundation at the centre, denoting that it is Ranginui (the sky, the father of all things) and Papatūānuku (the earth, the mother of all things) that together, enable humanity to thrive.

www.projectmoonshot.city

Source: An indigenous Māori view of Doughnut Economics

URGENCY AND COMPLEXITY IN ADAPTATION

Lauren Rickards, the Director of La Trobe Climate Change Adaptation Lab presented to the Adapting Aotearoa audience on the urgency and complexity of adaptation. Both Australia and Aotearoa New Zealand are at risk of:

- Cascading, compounding, and aggregate impacts on cities, settlements, infrastructure, supply chains, and services
- Institutions and governance becoming unable to manage climate risk
- Loss of natural and human systems in low-lying coastal areas

These risks are unevenly distributed, perceived variously, and rated against each other. We all occupy and act upon a dynamic 'landscape' of real and perceived risks. For farmers, a typical approach to diagnosing climate change risk is to focus on only a few elements at a very local level. When combined with access only to national averages of modelling, it is difficult to understand the particular risks to a particular farmer.

Lauren emphasized that adapting agriculture requires, and is a route to, the sort of systemic adaptation the world needs.

Farmers, researchers, and government need a sophisticated understanding of the risks each other face. At present, if Aotearoa New Zealand is a lighthouse, we are all seeing through our own particular directional "window". There is no comprehensive view – just individual lights searing through the dark. Farmers, researchers, and government all need a 360 degree comprehensive view, with each window filtering the light differently .

To understand what is at risk in the agricultural system everyone involved needs to look through all the available windows. The 'windows' Lauren discussed included:

1. *More climatic changes*
2. *Direct climatic impacts on other elements of the farm*
3. *Impacts on the regional socio-technical systems farms rely on*
4. *Impacts on the national and international socio-technical systems farms rely on*
5. *Impacts on the socio-ecological systems farms rely on*
6. *Existing non-climatic vulnerabilities*

Each of these is discussed in more detail below.

MORE CLIMATIC CHANGES

What comes into view:

- More frequent and intense climatic extremes and weather events e.g. droughts, floods, storms (intense rain and hailstorms), frosts, heatwaves, fires
- Altered seasonality and climatic variability over months to years
- Altered runoff including streamflow, shifting the geography of the freshwater system and the status of water storages
- Sea level rise, coastal erosion, coastal inundation and salinisation of river systems and coastal aquifers
- Warmer and lower quality water bodies, altered currents
- Biophysical flow-on effects in the near and long term, including weeds, pests, algae and disease, biodiversity loss, and degradation of soil.

Overall we need multi hazard, resilience thinking, that allows farmers to reduce and recover from the impacts that are occurring now, while doing longer term climate change adaptation.

DIRECT CLIMATIC IMPACTS ON OTHER ELEMENTS OF THE FARM

Other elements of the farm system that will be directly affected by climate change include:

- The farm 'family' including, farm owners, managers, employees, and working animals
- Farm equipment, e.g. tractors, water pumps, irrigators, milking machines, shearing machines
- Farm infrastructure, e.g. vehicles, fences, buildings, tracks, dams, feed storage

Understanding a particular farm's climate sensitivity requires comprehensive, intricate, timely knowledge of it. The Australian Government has recently introduced a drought resilience self-assessment tool for farms. This encompasses the 'resilience signals' for a farm alongside the individual farmer's values and goals. Something similar for farmers within Aotearoa might prove useful.

REGIONAL SOCIO-TECHNICAL SYSTEMS

Adaptation for primary industries needs to be wider than farm plans, it requires a place-based, regional approach that encompasses:

- workers as community members, e.g. family responsibilities, ability to get to work, etc.
- wider farm community, e.g. farmer networks, advisors, vets, suppliers, etc.
- wider sector businesses, e.g. processors, irrigation infrastructure, transport, etc.
- community resources, e.g. marae, voluntary sector, schools, banks, health services, etc.

NATIONAL AND INTERNATIONAL SOCIO-TECHNICAL SYSTEMS

These systems are inter-dependent and networked, including communications, financial services and markets, data storage and processing, higher education and research, energy, transport, water and sewage. These systems make up so-called critical national infrastructure. However, the question needs to be asked: "critical for who"? Often infrastructure has an inbuilt urban bias that is blind to local rural linkages.

Reliance on these systems can also increase risk, for example supply chains services commonly use 'just in time resourcing' that can increase productivity and decrease waste, but at the same time has eliminated back up supplies.

We need a multi-scale view that appreciates and adapts the links of practical importance to farming, farm families and other primary industry stakeholders. This will require a cross-sectoral approach with a practical focus.

SOCIO-ECOLOGICAL SYSTEMS

The effects on ecological systems resulting from climate change are felt at miniature to global scales. These impacts are wider than just biodiversity on individual farms and can include alterations in viruses, predators, water catchments, and environmental flows.

Collectively, environmental sustainability needs to be a foundation of successful climate change adaptation outcomes – above and beyond specific "nature-based solutions".

EXISTING NON-CLIMATIC VULNERABILITIES

Existing stresses and problems are exacerbated by climate change and its impacts. This is especially true where bias and inequity make people vulnerable. The interactions include:

- Climatic hazards & interactions, e.g. hotter conditions and heatwave
- Exposure, e.g. location and quality of urban development, mobility patterns
- Vulnerabilities, e.g. precarious work, poor health, colonisation, digital divide, long complex supply chains, metro-centrism.

Any adaptation needs to redress existing vulnerabilities alongside avoiding worsening hazards and dangerous conditions. For example, many farmers experience patchy internet connectivity on farm, where the connection to their house may be fine but connectivity is unavailable in their paddocks. Adaptation provides the opportunity to redress long-standing problems.

FEEDBACK FROM INDUSTRY

The relationship between research, scientific discovery and the nuts and bolts of policy is complex, but there are examples already of where this works well, where that thinking is being done, where that practice is happening and how policy levers are being used to bring about change.

Less clear is how scientific research can be used directly on farm by those at the front line of food and fibre production. The workshop and panel elements of Adapting Aotearoa made clear a serious divide in worldview between scientists and farmers.

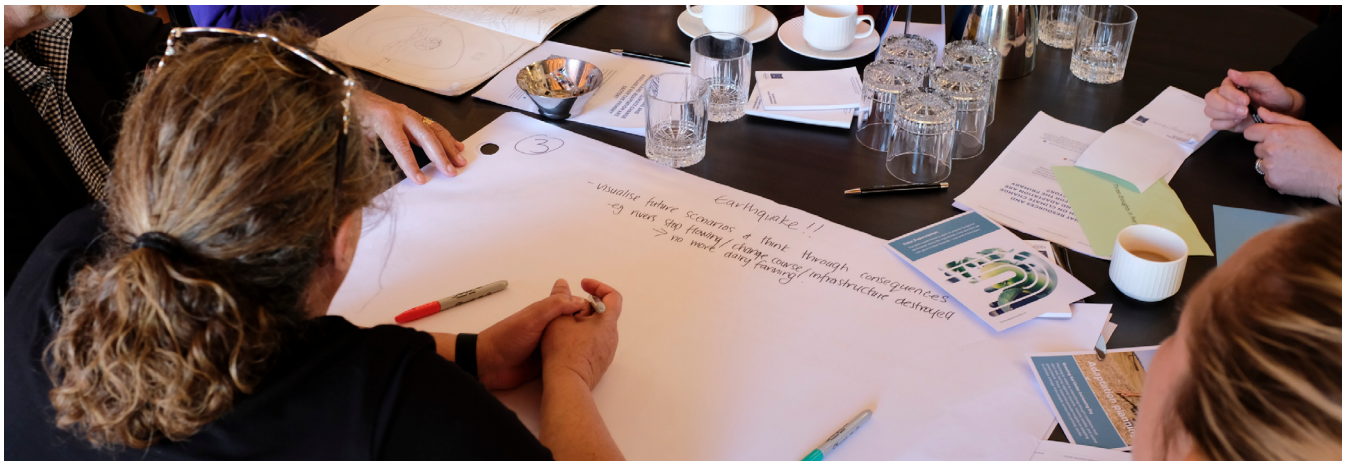
Innovation and constant modification for improved results are a staple of farm practice in Aotearoa New Zealand. A successful farmer responds to what is in front of them with careful forethought and deep consideration of the land's sustainable environmental and economic future. Farmers are responding to changes in the climate as they have always done. They continue to alter their practices in incremental but vital ways as responses to natural hazards and changing conditions become practical.

Below are some practical steps that were suggested during the Adapting Aotearoa symposium. These suggestions emanate from discussion in the panels, notes taken at the table workshop, and feedback from the post-event questionnaire.

ACCESS TO KNOWLEDGE

While science has an ever-improving understanding of adaptation needs, there has been little information about upcoming change at a local farm level communicated to those at the farm gate. National modelling fails to connect with farmers, who need practical understanding of the potential effects of climate change on their own particular landscape, buildings, soil, herd, flock or crop. Understanding specifics is inherent in planning for farming.

One workshop group suggested that digital twin technology could be helpful in showing farmers what their farm will look like in 30 years. This would allow them to understand the farm's vulnerabilities.



"We don't need to pilot the research on farm if it can be modelled."
"…. need easily accessible shared spatial temporal datasets - current and projected - to allow faster progress on possible futures when working with farmers and landowners."

Feedback questionnaire.

The science and its uncertainties may better be filtered through specialist land managers and farm advisors. This would ease access to complex knowledge and systematically improve farmers' ability to understand what data is validated and relevant.

It is clear that farmers prefer to learn from farmers. This requires a regional approach and an examination of whether the current industry bodies serve farmers' adaptation needs. A suggestion was made for funding multidisciplinary research and outreach teams in long-term partnerships with industry, communities, and policy advisors. This knowledge capital infrastructure would allow exploration of issues, options, and recommendations.

One group made a suggestion to increase the ability of the Ministry of Primary Industries' On Farm Support scheme to support farmers in this multi-disciplinary way with a focus on understanding regulatory needs and the available data and projections. This existing scheme could also take better advantage of existing farm managers working in commercial organisations such as Fonterra and Merino NZ, who provide education and advice for their contracted farmers and suppliers.

Develop an industry genetic plan for future climates. This would ensure farmers have options to turn to when current genetics are no longer suitable.

Other suggestions included the establishment of a Future Generations Commissioner, being tougher on 'environmental crime' and legislation to help with farm debt incurred in adaptation.

POLITICAL CYCLE

There was acknowledgement that the short-term nature of the political cycle led to uncertainty around legislation, consenting, and guidelines. This makes it hard for farmers to keep up with requirements while planning for the long-term.

"Most of our decisions are on a [political] three-year cycle. Fifty years is more realistic for change, but climate change is urgent."

Symposium participant

There was a plea for a national vision that transcends political cycles – in particular elucidating where the responsibility and support for change belongs, with producers or consumers? Reluctance was expressed by one group to change direction while demand for existing services was still in place.

"Should we respond to market signals or the planet's signals? Where does the responsibility for transformational change lie? Is it with the consumer or the producer? The impact of consumer behaviour is driven by price and convenience regardless of actions of food producers."

Symposium participant

There was a suggestion that government should incentivise farmers to bring green energy solutions and water conservation initiatives to their buildings. This would make farms more self-sufficient in emergencies as well as aiding in climate mitigation. Funding and support for this initiative could be modelled on the Healthy Homes Standards or Warmer Kiwi Homes grants.

DISTRIBUTED INFRASTRUCTURE

There was widespread acknowledgement that, particularly in rural locations and for marae, communities are often self-sufficient and not so reliant on incentives, regulation, and external support. Difficulties tend to emerge when any emergencies are more widespread or long-term, especially if supply chains are affected.

Part of the distribution of infrastructure discussion centred on choosing the right crop for the right place, e.g. carrot group in Ohakune and Southland. Put annual vegetables on floodplains and orchards on higher ground.

A majority of attendees thought national infrastructure should be locally managed so the community can become truly self-sufficient, without a need to import "everything". Emergency food stores were also suggested.

> *"An urban approach is being applied to rural activities. It's not an appropriate fit. We need to prioritize domestic food supply."*
>
> *Feedback questionnaire.*

It was suggested that planning conversations were best held at catchment level, enabling a systems shift with support for diversifying land use and building long term resilience.

> *"The key thing that will lead to transformative change in the climate adaptation space is for councils to be given a mandate from central government to consider adaptation and domestic food supply."*
>
> *Feedback questionnaire.*

There was an in-depth discussion about the pressures faced by the rural farming system that make it very difficult to move to regenerative approaches. Encouraging urban food growth could be the first stage in changing this. The next step would be to transition towards new locations and places to live that are in climate change 'safe' locations where communities can generate their own food, energy, and water. Reducing the barriers to local renewable energy (both generation and storage) would be an integral part of this strategy.

CHANGING HOW WE LOOK AT VALUE

Much of the discussion in this area was captured in the Ko Papa Ko Rangi rolling symposium, but participants echoed and emphasised much of what was discussed in the report. This included the need for a longer-term whole systems thinking vision that incorporates mātauranga Māori and multi-generational thinking (and resourcing).

> *"We need to start valuing environmental, social, and cultural wellbeing as much as we do economic."*
>
> *Workshop write up*

> *"Shifting my engagement with the environment from an extractive one to a relational one."*
>
> *Workshop write up*

A particular call was made for farming groups and government to work with banks and insurers on planning. The group saw it as key that financial constraints for farmers engaging in resourcing adaptation plans were eased. Elements discussed here included mortgage discounts for future-proofing and different methods of monitoring cash flow. Any change to a more collective way of working is also something that would require alteration to financial service requirements.

> *"It's going to require a high level of collectivism, e.g. community food shops and shared collective facilities - the commons not individualism for food, recreation, tools, etc."*
>
> *Workshop write up*

PUBLIC EDUCATION

The discussion in this area was wide ranging, encompassing encouraging and improving agricultural and horticultural education within the school system and bringing local communities onto farms so they better understand how they work. Celebration of success stories and case studies was also mentioned.

RESEARCH AND MANAGEMENT AT OWL FARM

Owl Farm is a joint venture between St Peter's School in Cambridge and Lincoln University. It was created as one of three demonstration farms in Aotearoa New Zealand, with funding from partners Ballance, DairyNZ, Fonterra, PGG Wrightson Seeds, and Westpac. This report uses Owl Farm as a case study to demonstrate how incremental change in response to observations can be incorporated into longer term planning, using a mixture of observations, on-farm monitoring and use of scientific research.

Owl Farm's 160 hectare section gives students at St Peter's school practical experience of farming, as well as providing leadership to the dairy sector through implementing progressive practices. Its objectives include achieving a sustainable environmental footprint and optimising profit.

"PROGRESS BEFORE PERFECTION."

Owl Farm aims to think proactively about how to adapt to climate change now and into the future. Through collection of scientific data on nitrates, DNA stock, and emissions alongside on-farm observations of weather patterns, they know change is already occurring. Specifically over the last eight years of data, they have observed that:

- The seasons are changing with the soil temperature 'hot window' now extending from October to April rather than January to March.
- Average soil temperature at peak is two degrees warmer
- There are more days where heat stress is a potential issue for cows
- An observed variability in annual rainfall that impacts crop or forage selection choices.

Animal wellbeing and productivity are already affected by these changes and Owl Farm, like many other farms, is adapting to the changes they are observing. They are also planning for changes into the future that could require more significant or transformative shifts.

A Deep South funded project, Primary Sector Preparedness to Climate Change, is working alongside Owl Farm to support their planning for future climate change. Together they have used principles from dynamic adaptive pathways planning, such as identifying triggers that would indicate the need for a change in practice or the introduction of a new adaptation measure. This process also allows them to identify lead times for more transformative changes.

One of the key climate change related concerns for Owl Farm is heat stress for livestock. Some of the changes they have already made include:

- An extensive tree planting programme to provide shelter for cows during hot temperatures (as well as generating other benefits, including biodiversity and emissions reductions).
- Changing the sward to grass with deeper root stock to better cope with large rainfall events and drought.
- Investigating aquifers and proving more drinking water for livestock, including remote monitoring to check and maintain the flow to ensure it is sufficient.
- Installation of sprinklers in the yard.
- Adjusting milking times during hot days to protect livestock and workers from heat stress.
- Planning for shade when allocating feed, to ensure that cooling cows do not miss out on pasture.

These changes generate benefits in the current climate and buy time for Owl Farm to continue their current system as temperatures increase.

As a demonstration farm, Owl Farm has the support of industry partners with wide ranging knowledge. This has provided them with a level of understanding of regulatory and resource requirements and enables a certainty around the farming parameters they operate under. Owl Farm also contracts a regular farm consultant to help with inputting and interpreting data via FARMAX, which provides a greater level of understanding of triggers and risk. They have also adopted many of the new monitoring technologies, including soil moisture and weather data along with cow wearables to monitor health outcomes, and regionally-based projection modelling through the Deep South National Science Challenge.

Owl Farm has used cash flow to pay for substantial changes in their infrastructure and biological systems. They embed an extra 15-20 percent of cost into their systems, this is supported by bank discounts that recognise the future-proofing elements of their investment.

In this process of adaptation planning, Owl Farm has identified that keeping records and monitoring changes and trends are critical in allowing farmers to understand when thresholds are drawing near. Knowing the lead time for the implementation of each specific adaptation means that farmers will be ready to spring into action when required. The overall process of identifying, planning and sequencing options allows farmers to adapt to current changes and keep their options open, while being prepared for when climate changes become more intense.

At some point however, such adaptations may reach the limit of their effectiveness and additional changes will be required. For example, transitioning to a “slick” gene that produces animals more tolerant to heat is an option in the future, but these animals may suffer more from the cold so this change would only be suitable when winters are demonstrably warmer, and/or more shelter is available for calves.

Although Owl Farm is firmly committed to dairy farming into the future, there may come a time 20 to 50 years in the future when the suite of available adaptations may indicate that other opportunities are better for the land or more advantageous for the business. At this stage, options like diversification or land-use change may provide greater resilience in a changing climate.

ON THE WAY TO SYSTEM-LEVEL CHANGE

The primary sector is ripe with solutions to climate issues and innovative responses to our warming planet. It is accustomed to responding to natural hazards and experienced in dealing with changing conditions. However, incremental change without access to long-term advice and planning can only keep up with a changing climate for so long.

Continuing with reactive marginal change in response to extreme weather events as they occur leaves farmers exposed to a 'reality bites' scenario with growing numbers of stranded assets and extensive adverse economic impacts. A continuation of incremental change in response to retrospective data could end with the agricultural sector being 'acted upon' or forced into decisions based on economic deprivation. Without pre-emptive planning farmers are more likely to be exposed to extreme regional price variability, declining soil and environmental conditions, supply chain constraints, national reputational risk, and lack of access to insurance and investment.

In the best-case scenario, farmers, researchers, and government would work together to bring about an 'ambitious transition' through clearer understanding of local on-farm impacts and adaptation needs. This understanding would be echoed in the support of financial institutions and resource managers. Productive land use would be at the centre of local economies, with food production highly valued. Domestic production would be aligned with land use capability, as international and domestic consumers place priority on farming within environmental limits. Landowners would be able to take advantage of new markets in biodiversity credits.

For the agricultural sector, proactively adapting to climate change is:

- **Essential:** if the agricultural sector wishes to survive and thrive, adaptation is imperative.
- **Extraordinary:** the transition to a future where the agricultural sector thrives in the face of a changing climate will require unprecedented, innovative, and remarkable work that builds on current success.
- **Existential:** each farmer is responsible for their own actions and must act to affirm the agricultural sector's continued existence and value.

We need to bridge the gap between farmers' understanding of incremental change and response and the need for research-informed transformation. This requires researchers and the agricultural sector to work together to reduce the dissonance between their two viewpoints and create practical, locally-applicable actions to adapt to the coming climatic changes.

FUTURE RESEARCH

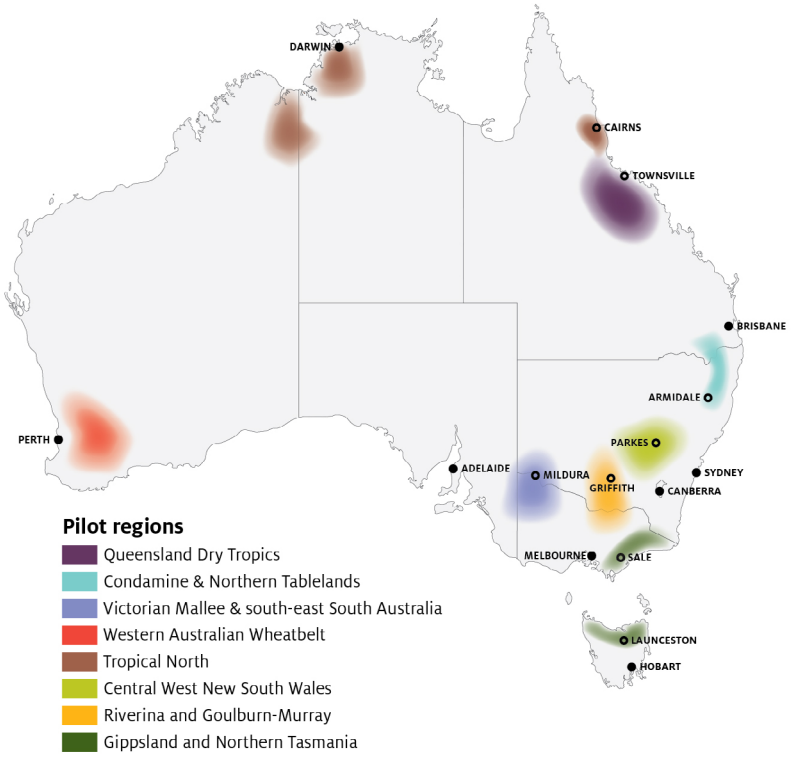


Image from the Australian *Drought Resilience Self-Assessment Tool*

The following points summarise future needs identified through the symposium:

- More opportunities for discussion to bridge the gap between research understanding and agricultural practical implementation. This should include:
  - ongoing symposia where the dissonance between viewpoints is discussed and a common understanding of actionable steps is formed
  - more collaborative research where questions are co-designed by farmers and researchers
  - more granular, locally-focussed data (possibly including digital twins) – recognising also the potential for false precision with down-scaled climate projections.
  - a stronger two-way flow of information between practitioners and scientists
- Understanding of decision-making triggers and the timelines for these triggers for each industry, so these can be put into practice.
- Something similar to the Australian Government's drought resilience self-assessment tool for farms – that could also include flood and landslide
- Working with banks to increase cash flow for adaptation and future-proofing
- Research into the likely effects of climate change on a wider range of species within agroecosystems from core crops and animals to trees on farm, mycorrhizae, competing weeds, insects, and pathogens, etc.
- Natural hazard models that incorporate climate change (i.e. landslides, flood maps).
- Planning conversations between the agricultural sector and government at a catchment level.
- A public debate on the role of genetic modification technologies in combating climate impacts.

RECOMMENDATIONS FOR POLICYMAKERS

Out of the symposium the DSC leadership team has developed recommendations relevant for policymakers, thee to come out of the symposium include:

- **Create opportunities for national-level meetings between farmers, researchers and policy-makers to encourage the understanding of different viewpoints and needs.** Prior to Adapting Aotearoa there have been few (if any) opportunities for the primary sector to collectively focus on adaptation (rather than mitigation) across these three groups. The discussion needs to be continued and built on.

- **Resource central government funded, locally-focused farm monitoring and extension to encourage informed, individual farm-based planning on a 5-50 year scale.** Adaptation requires new (and sometimes reviving old) management practices, and it is clear from both the research as well as farmers' feedback, that not all farmers currently have these skills and knowledge. Rural extension professionals also require training and understanding of the evolving climate and ways of thinking for a adapting to a very different future.

- **Investigate funding of green energy solutions and water conservation initiatives for farm buildings.**

- **Hold planning conversations at a catchment level.** Local knowledge is essential in ensuring planning and regulation are effective, efficient, and equitable. This is critical to ensure engagement and buy-in from local

APPENDIX 1: RESOURCES

WHAT IS LIKELY TO CHANGE LAND USE IN NEW ZEALAND?

Primary sector leaders agree climate change is the key challenge most likely to change land use in Aotearoa New Zealand, found the 2022 'Matrix of Drivers' report by Our Land and Water. This places it significantly higher in importance than all other factors, including the ongoing impacts of the Covid-19 pandemic. The 2023 edition of the report was to be released by end of 2023.

RURAL COMMUNITIES AND ECONOMIES

WORKFORCE IMPLICATIONS OF LAND-USE CHANGE

Investigates how regional workforce capacity will affect the suitability of different land-use types. It also covers strategies and interventions that could mitigate workforce constraints, such as counter-seasonal production. This is relevant to new land-use opportunities that could be created under climate change – as they can't be taken up if the workforce isn't available.

CLIMATE CHANGE AND DROUGHT: THE FUTURE OF FARMS AND RURAL COMMUNITIES

Draws on 70,000 tax returns and temperature and soil moisture data to understand the historical relationship between local weather and farm profits. The research found a strong relationship between more intense future drought and reductions in farm profit, for both dairy and sheep+beef farms.

SUPPORTING LAND USE ADAPTATION TO CLIMATE CHANGE

Uses farmer workshops and interviews, to identify barriers, gaps and constraints that limit Canterbury farmers from exploring land use options suitable for a changing climate. The research suggests the convergence of water use consent renewals and dairy shed renewals may be a catalyst for landuse change in mid-Canterbury around the early 2040s.

DISASTER RESILIENT OUTCOMES FOR RURAL AOTEAROA

Breaking out of 'non-decisions' for primary industries

Current policies guiding the recovery of primary industries after natural hazard events may have unintended long-term consequences, by preserving the status quo and locking in undesirable pathways. This workstream uses three case studies; Southland (drought), Marlborough (drought and earthquake) and Bay of Plenty (flood), to gain insight into recovery in rural settings and identify opportunities to enable more resilient responses.

Protection and recovery from localised natural hazard events

This case study is investigating the recovery path of farmers and rural households affected by adverse events in the Hawkes' Bay region. The aim is to identify potential tools that could increase preparedness, reduce risk and aid recovery for farmers, industry groups and relevant agencies.

CLIMATE RESILIENT FORESTRY AND HORTICULTURE

To help landowners in Te Tairāwhiti reduce the risks of increased erosion under climate change and to maximise their revenue, this project used kaupapa Māori, bio-physical and economic assessment tools to understand and evaluate different land-use decisions within a range of potential climate change scenarios. The team worked alongside landowners to identify multiple landuse opportunities with a range of social, economic, environmental and cultural benefits. These included alternative forestry options, horticultural options and other medicinal and cosmetic business options derived from mātauranga Māori. This research found that re-foresting the land – particularly with indigenous species – would result in a significant reduction of soil erosion for the Waiapu catchment, as well as helping realise the core values and aspirations of Māori landowners.

HIGHER CARBON PRICES: IMPACTS ON FARMING AND FORESTRY WHĀNAU

Higher carbon prices are likely to lead to permanent carbon forests and a reduction of mahi on farms and in production forests. This will almost certainly impact whānau working in farming and forestry. This project was designed to ensure that our hapori in Te Tairāwhiti understand and are prepared for the risks and opportunities posed by permanent forests. This research focused on whānau engagement around our level of understanding about and responses to likely forestry scenarios. It aims to ensure that the perspectives and priorities of affected whānau and hapū shape public policy at the local, national and international levels. Various engagement resources are available from this project.

ENHANCING RESILIENCE AND WELLBEING

The speed and extent of recovery from natural hazard events often vary significantly across communities depending on factors such as socio-economic status, the level of external support and aid, past experience of disasters and the nature and severity of the disaster. We aim to obtain a deeper understanding of the contextual nature of vulnerability and provide additional insight into effective pathways for addressing the underlying causes of risk, to enhance wellbeing and resilience in the face of disruptions and shocks. Case studies on topics including regional food security are providing new insight into the factors that enhance wellbeing and contribute to resilient communities, focusing on the social connectivity, networks and relationships that bind individuals and communities together. Our overall goal is to increase the capacity for communities to bounce back from immediate shocks and help them proactively respond to slow-building changes.

SECTOR-BASED IMPACTS AND ADAPTATION

PRIMARY SECTOR PREPAREDNESS FOR CLIMATE CHANGE

Collaborating with Dairy NZ and working with farmers from Otago, Southland and the Waikato, this multi-disciplinary project incorporates hydrological, biophysical and economic modelling, risk analysis and qualitative social science to develop a picture of the impacts of climate change and the options for and implications of adaptation. The analysis spans the farm scale through to regional, national and global scales, and provides a comparison of the implications of climate change for the upper North and the lower South Islands.

WHITIWHITI ORA: LAND USE OPPORTUNITIES

This project aims to help land stewards assess diverse land use opportunities and make decisions with confidence so that both the whenua and its people will prosper.

The climate change aspect of this project aims to give land stewards a greater understanding of the most suitable crop options for their land, by modelling the impacts of climate change on key land uses and agricultural concerns. It follows on from the Deep South Challenge project Climate change and its effect on our agricultural land.

The team used biophysical modelling to understand the critical climate attributes of various fruit and vegetable crops. It also developed national maps of the climate impact on:

- Crop suitability and phenological stage of various fruit and vegetable crops,
- Risks of several animal health issues such as facial eczema and Barber's pole worm; and, » physical implications of climate change relevant to the primary sector, such as sediment load in rivers, erosion and annual potential evapotranspiration deficit (drought).

The national maps and data produced by this joint work are being uploaded to the "Data Supermarket" as they become available.

SECTOR-BASED IMPACTS AND ADAPTATION

CLIMATE, WATER AND WINE: ENABLING ADAPTATION TO INTERACTING STRESSORS

Focusing on the Marlborough Region, this project is assessing the combined effects of climate change and changing water availability, and what's required to secure future sustainability. Working with land managers and others, the team is developing a sector-specific pathway to ensure emerging risks and opportunities are managed effectively. The research employs viticultural and soil-water modelling, geospatial analysis and integrated scenarios of change, combined with in-depth, qualitative research. The aim is to document the decision context, identify strategies and sequence adaptation options over time.

CROP DISEASE UNDER CLIMATE CHANGE

Projects change in crop disease risk by integrating the latest climate change scenarios with disease risk and plant phenology models. An economics team will investigate the potential impacts on our global agricultural markets, and on producer and consumer prices in Aotearoa New Zealand. This project will create an interactive tool via HortPlus's Metwatch that will provide farm-scale climate information.

LAND USE FOR NUTRITIOUS DIETS

Tested future scenarios for land-use change to see whether it's possible to design a 'win-win-win' plan for future food production. Could we produce the right crops, in the right places, to feed all New Zealanders a healthy diet, while reducing greenhouse gas emissions or freshwater contamination, and minimising the financial impact on families and farmers? The short answer is yes.

ADDITIONAL RESEARCH PROGRAMMES

There is much research outside of the National Science Challenges also, for example:

THE MINISTRY FOR PRIMARY INDUSTRIES' SUSTAINABLE LAND MANAGEMENT AND CLIMATE CHANGE FUND (SLMACC)

This fund aims to support research that helps the agriculture and forestry sectors with challenges arising from climate change.

EXTREME WEATHER RESEARCH PLATFORM

In February 2023, as part of the ongoing response to extreme weather events in the North Island, the Ministry of Business, Innovation and Employment (MBIE) reallocated $10.8 million for urgent scientific research and data collection. The funding was distributed across several different projects and is being coordinated by Climate Sigma and the Resilience to Nature's Challenges National Science Challenge.

APPENDIX 2: PODCASTS AND WORKSHOP SUMMARIES

This rolling symposium consisted of two preliminary podcasts and culminated in an all-day event. The aim was to generate evidence-based conversation around the economics of adapting to climate change.

ADAPTING AOTEAROA WEBINAR 1: CLIMATE CHANGE IMPACTS IN THE PRIMARY SECTOR

7 November 2023. Watch here.

Kathryn McRae, Senior Scientist, AgResearch: Predicting disease risks for sheep farmers in a changing NZ climate.

Pierre Beukes, Farm Systems Modelling Team Leader, DairyNZ: Potential impacts of climate change on pasture growth, annual yields, and farm performance in the upper North Island and the lower South Island.

Heather Craig, Lecturer in Disaster Risk & Resilience, University of Canterbury: Exposure and impacts to dairy farms in Aotearoa from climate change-driven sea level rise and extreme events.

ADAPTING AOTEAROA WEBINAR 2: ADAPTATION IN THE PRIMARY SECTOR

13 November 2023. Watch here.

Christina Griffin, Research Fellow, University of Melbourne: Barriers and enablers of climate change adaptation on dairy farms, drawing on interviews with dairy farmers in the lower South Island and Waikato regions.

Richard Fitzgerald, General Manager of Enviro Collective Ltd: Supporting land-use adaption for a climate changed future: A regional cross-sector approach.

Nick Cradock-Henry, Principal Social Scientist, GNS Science: Navigating future uncertainty in the primary sector.

ADAPTING AOTEAROA SYMPOSIUM: TOWARDS A CLIMATE RESILIENT LAND AND FOOD SYSTEM

20 November 2023. Watch here.

This in person day-long event brought together researchers and stakeholders from the primary sector, academia and government to explore innovative solutions for building climate resilience and deeper understanding of the urgency for adaptation in our agricultural practices.

Opening address: Anne Haira, Ministry for the Environment: The importance of adaptation

Keynotes: Lauren Rickards addressing the urgency and complexity in adaptation with insightful perspectives from Australia, followed by Rod Oram on global context and perspectives.

Panel 1: *Enabling transformational adaptation in the primary sector:* Possible, Plausible, Preferable? Are there limits to adaptation in Aotearoa? Is it plausible: and if so, what is stopping us? And just what IS the future we want? Nick Cradock-Henry, John Reid, and Jenny Christie will present short talks on hot topics before being joined by Lauren Rickards and Rod Oram for a robust panel discussion on the challenges of enabling effective adaptation.

Panel 2: *Adaptation in action – using research to adapt and transform*. Jo Sheridan, Kate Ackland, Tasman Gillies and Hilton Collier will present short talks before opening up into a panel discussion on how to use research to adapt and transform from a practical perspective.

Workshop: *Future directions*. A brainstorming session to ensure we have captured questions that haven't been answered, gaps in knowledge and research, contradictions and paradoxes, and to explore some practical options for change in your everyday work.

Panel 3: *Incentivising action*. Jack Bisset, Karen Lavin, Tim Henshaw and Trecia Smith will present short talks before opening up into a panel discussion on how government, regulation and business can support adaptation and incentivise action.

APPENDIX 3: ABOUT DEEP SOUTH/ TE KŌMATA O TE TONGA

The National Science Challenges were established in 2014 with the aim of tackling the biggest science-based issues and opportunities facing Aotearoa New Zealand. The Challenges bring together some of the country's top researchers to work collaboratively across disciplines, institutions and borders to achieve their objectives. The Challenges represent a new way of funding research, with five key principles making them unique within the science system: they are mission-led, focus on science quality, bring together best research teams for collaboration, invest strongly in stakeholder engagement and public participation, and prioritise Māori involvement and mātauranga.

The Deep South's mission as a National Science Challenge is to enable New Zealanders to anticipate, adapt, manage risk and thrive in a changing climate, by funding and engaging with research through four programmes: Vision Mātauranga, Impacts and Adaptation, Processes and Observations, and Earth System Modelling and Prediction. More information on the Deep South Challenge can be found at www.deepsouthchallenge.co.nz.

Changing with our climate

START ADAPTATION PLANNING TODAY