Climate Change Impacts and Implications for New Zealand to 2100

Synthesis Report: RA4

Enhancing capacity and increasing coordination to support decision making

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Rakaia River: The cover image is used to illustrate the dynamic and changing nature of decision implications arising from climate change in New Zealand and the different pathways they can take across different domains such as freshwater resources, coastal, urban and rural settings, industries and sectors and levels of governance and institutions.

Cover photo: Nelson Boustead, NIWA

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CONTENTS

HIGHLIGHTS

This report presents evidence about the impacts and implications of climate change that have decision relevance for a range of stakeholders. Collaborative and participatory research methods were used to engage with a wide range of stakeholders to better understand the decision landscape affected by climate change impacts and implications. The evidence supports the development of new practices for addressing and planning for climate change impacts and implications in New Zealand. The relationships developed will enable a strategy to be built in order for adaptation practice to mature, and to develop a shared understanding of climate change impacts and implications across public, private, and influential actors and agencies.

1) Understanding and information

Perceptions of climate change are dominated by short-term thinking in all but a few sectors, and on 'familiar' risks. The interaction between climate change and other risks, however, will require new strategic approaches to risk management and a greater emphasis on dynamic and emerging risk profiles.

More information is required to support the adaptation decisions of stakeholders in dynamic social and economic contexts that will be affected by climate change. Information needs and knowledge gaps include understanding future risks for a range of decision-relevant variables; climate change implications for a greater range of stakeholder interests and information to support adaptation decision-making in dynamic social and economic contexts.

2) Effects

Climate change will have direct impacts on primary economic activities and have indirect implications for a range of sectors including hydro-electric generation, tourism, commercial forestry and agriculture. Implications are particularly acute for urban areas facing the combined effects of rainfall extremes and sea-level rise, to which legacy infrastructure may be ill-suited. Climate change will create dynamic risk profiles, demanding a more strategic management approach. However, with a few notable exceptions, the private sector has done little to consider changing climate risks on business operations, and serious questions about public and private adaptive capacity remain unanswered.

Climate change will also create cascades of implications, resulting in a chain of events affecting multiple system domains, including governance. Rainfall extremes can disrupt productive land uses, affecting quality and yield, with implications for transport networks, port access, trade, and economic exchange. Increased irrigation and shifts in land use in response to a drier climate, may result in pastoral farmers moving stock to steeper country, increasing runoff and erosion, with downstream water quality impacts. Such cascading impacts are identified.

There are functional linkages between land and water management, energy, and climate change that are often treated separately. Inter-basin water transfers and ground water pumping, for example, are energy intensive. Promoting them as a drought mitigation solution or to boost productivity may have implications for sustainability. Such 'nexus' issues also have social consequences. Urban and rural populations may place different values on freshwater than productive sectors, leading to growing tensions over managing this resource. Nexus issues have received only limited attention to date; the integrated tools and solutions required to guide decision making are, therefore, lacking.

3) Decision-making implications

Current tools are ill-suited for addressing the uncertainty and long decision time frames posed by climate change. There are dependencies between public and private sectors that are not commensurate with the strategic and inter-generational view that is required. This includes the 'legacy effects' of past decisions, changing risk profiles, regulatory frameworks and functional mandates that emphasise reactive and short-term decision cycles.

Governance - regulation, coordination and control to enable or constrain action and actors – is fragmented across scales, and between and within organisations, impeding adaptation efforts. There is early evidence of linked-up thinking in regional and territorial councils that developed over the course of the research, but coherent national objectives for climate change impacts

throughout New Zealand are vital. Institutional tools to support dynamic adaptive planning, and address economic and fiscal risks, are also needed.

Organisational capability falls along a spectrum, depending on size, focus, and degree of functional integration within agencies, and across governance levels. Capability and capacity to address climate change impacts and implications depend on management processes, self-efficacy, and resource mobilisation. Access to resources varies widely. Where skills and resources are available in-house, intra-organisational silos may limit the ability to address climate risks. The immediate focus of smaller councils and businesses limits the ability to address climate risk and make connections with other scales or sectors. Most risk management processes and practices are linked to specific issues; for example, fire risk or experienced risks, rather than to changing climate risk profiles.

4) Engaging with climate change in decision making

Governance, policy, uncertainty, resources, and psychosocial factors are the greatest impediments to more effective decision-making relating to climate impacts and implications. Mismatch of time horizons for adaptation decisions and political and management practices are the most significant governance barriers, while scepticism regarding the drivers and effects of climate change has, until recently, hampered strategic thinking. Meeting urgent information needs - including climate change guidance, improved monitoring and evaluation, and vulnerability and its drivers – can help support strategic adaptation planning efforts and avoid maladaptive responses.

Greater integration across governance levels and between societal actors is urgently needed. Opportunities to incorporate greater consideration of climate change impacts and implications into decision making are available, but have not been fully realised. Enhancing the linkages between statutory instruments, and identifying synergies between policy reviews and legislative reform, for example, can provide critical leverage points to help motivate change.

Tools and policy measures for decision making under conditions of uncertainty and change need to be deployed. Local government urgently needs to build decision capability and capacity, including enhanced networks, access to tailored and state-of-the-art climate information, and national measures to support climate change adaptation. NGOs and communities have a critical place in catalysing change by raising awareness.

INTRODUCTION

Overview of CCII

The CCII (Climate Change Impacts and Implications) programme had three objectives:

- Update and improve projections of climate trends, variability and extremes across New Zealand out to 2100, based on the latest global projections;
- Generate new knowledge about the potential impacts of climate change and variability on New Zealand's environment, including our natural ecosystems and native species, and productive systems which depend on the environment; and
- Generate new knowledge about decision making across the communities of practice, relevant for addressing climate risks, including how climate information is used and could be communicated.

These objectives were realised by way of five inter-related research aims (RAs):

Research Aim 1: *Improved Climate Projections*

Research Aim 2: *Understanding Pressure Points, Critical Steps and Potential Responses*

Research Aim 3: *Identifying Feedbacks, Understanding Cumulative Impacts and Recognising Limits*

Research Aim 4: *Enhancing Capacity and Increasing Coordination to Support Decision-making*

Research Aim 5: *Exploring Options for New Zealand in Different Changing Global Climates*

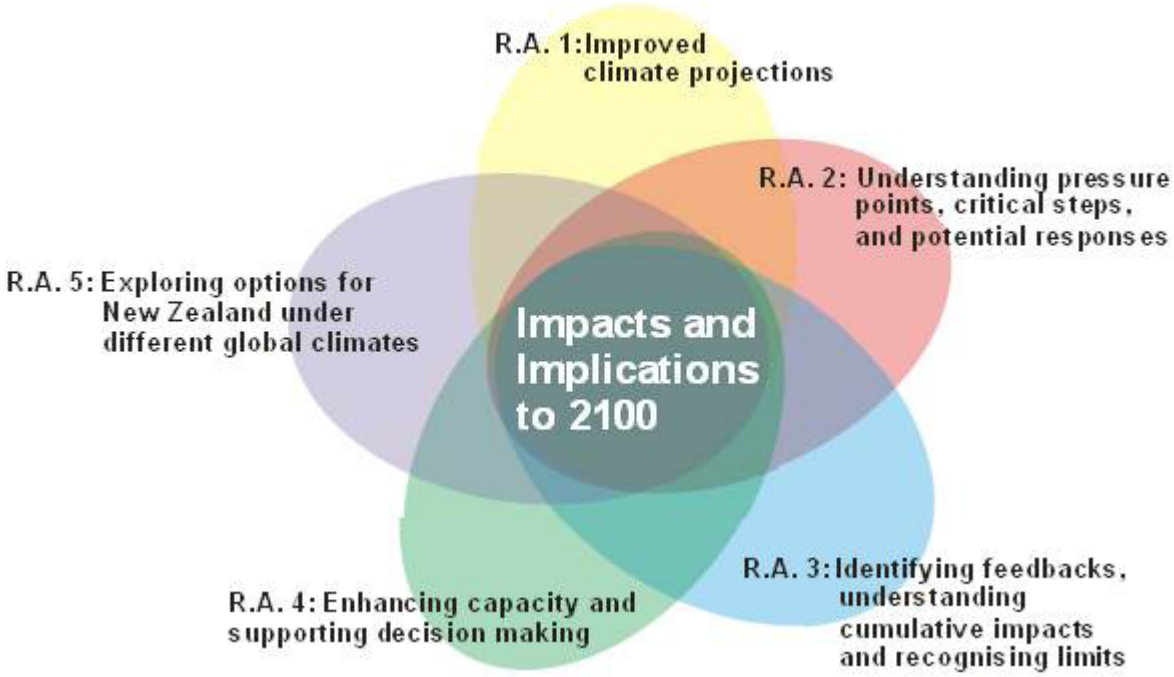


Figure 1: The CCII research aims and their interactions.

Overview of RA4 and report structure

To deliver on the overall research objectives, Research Aim 4 (RA4) focused on enhancing capacity and increasing coordination to support decision making. The goal was to gain insight into the significance of climate change in making decisions both now and in the future. The research was guided by the following questions:

- How can the emerging pressure points and policy and management implications of climate change and variability on the New Zealand environment, economy and society best be identified?
- How can climate change science provide decision-relevant information to adaptively manage climate change impacts, where risk profiles are changing, sometimes in uncertain ways, generating multiple possible futures?
- How can we best enhance the adaptive capacity of governments, business, iwi and communities to incorporate the implications of climate change, particularly for those facing the greatest risks or with the greatest opportunities?

Answers to these questions were collected and analysed over the four years of the CCII project. The report is structured as follows:

Section 1 contains a discussion of the research methodology and communities of practice approach and how an online questionnaire was developed. An overview of the key themes arising from the empirical data from interviews and focus groups with stakeholders is then presented, which forms the structure of the remainder of the report;

Section 2 discusses stakeholders' understanding and perceptions of climate change risks and information needs;

Section 3 discusses the effects of climate change on various sectors — the impacts and their cascading character and the nexus of land use change, climate change and water issues;

Section 4 presents the implications of climate change for decision making across activities, sectors and processes, including for governance and institutions and for organisational capability and capacity;

Section 5 discusses the barriers for engaging with decision-making processes and identifies critical leverage points;

Section 6 presents the conclusions of the report and the key findings; and

Section 7 reflects on key challenges going forward for research into climate change impacts and implications and its uptake to build adaptive capacity for decision making about climate change adaptation.

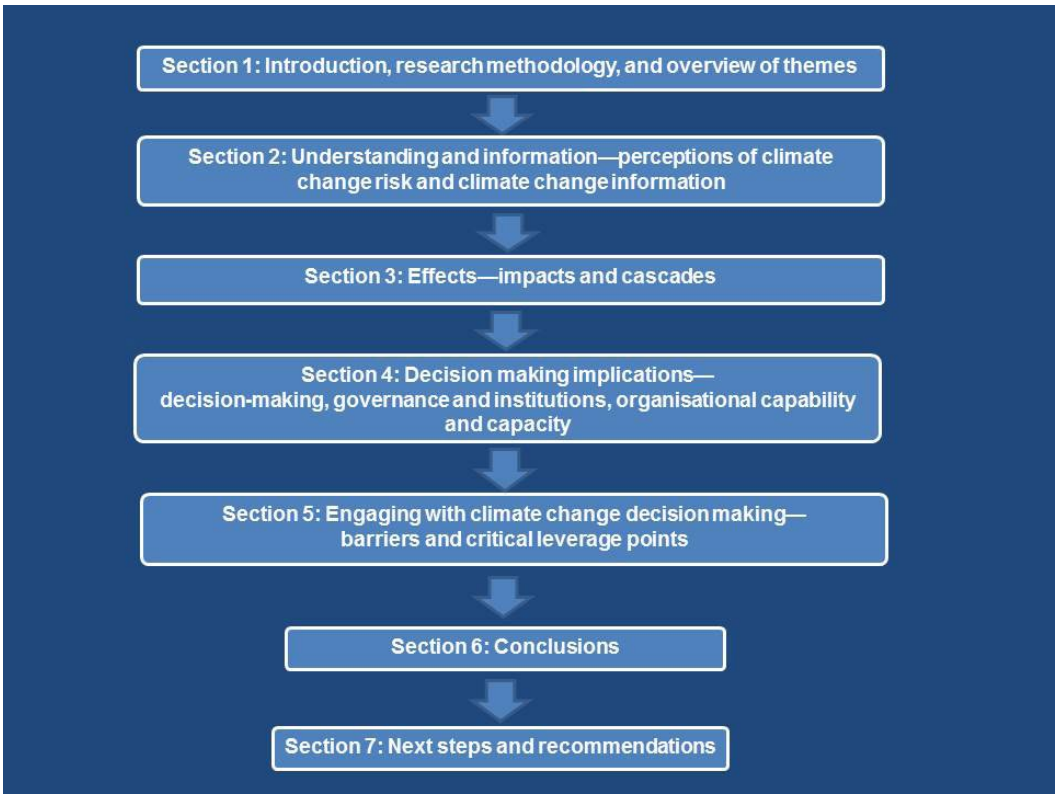


Figure 2: Report structure.

Research methodology

To answer the research questions, multiple qualitative methods were used including interviews, workshops and focus groups, and surveys to generate new knowledge about decision making across New Zealand. The focus was on the significance of climate change in making decisions, and whether and how participants were making decisions that would be affected by climate change impacts or how their decisions would affect climate change impacts.

As a result, the emphasis was on close collaboration with key stakeholder interests to co-produce climate change knowledge. Such a methodology 'fits' a problem that has layers of complexity as shown in the research questions. Iterative methods enable more in-depth examination of "what is going on" and the opportunity to find out more than can be elicited by surveys; for example, (Preston, Rickards, Fünfgeld, & Keenan, 2015; van Aalst, Cannon, & Burton, 2008). By using a co-production approach, it enabled the researchers to collect a broad and diverse data set across a range of sectors. This enabled the researchers to differentiate across sectors and to identify the flow-on effects across social and economic systems as a consequence.

Six design principles for knowledge co-production were developed to structure the research (Table 1) (Ross, Shaw, Rissik, & al., 2015; van der Hel, 2016).

There were two main objectives: to understand how climate trends, variability and uncertainty are understood by decision makers; and to identify influences on decision making that affects, and is affected by, climate change.

How climate trends, variability and uncertainty are understood

To evaluate the ways in which climate trends, variability and uncertainty are understood, we reviewed New Zealand local and central government policy and research reports. The aim was to identify how climate change impacts were being engaged with, why, and by whom, including the decision scales and organisational networks and interests involved. We examined how complexity and uncertainty were being discussed and addressed. We also examined the heuristics and techniques being used to communicate, visualise, frame, and represent climate-related information and concepts.

In addition to the document review, semi-structured interviews (n=52) were conducted with a range of stakeholders from the private (business) and public sectors, as well as influencer groups and some individuals from across New Zealand. Public sector agencies included those with statutory responsibilities (advisors and decision makers) to assess how they considered climate change and its effects and those affected by climate change impacts. We also examined

Table 1: Design principles for co-creating climate change knowledge

1 **'Open up' the production of climate change knowledge** by shifting from generalised, linear and detached ways of producing knowledge, to more context-sensitive, reflexive and situated ones.
2 **Co-produce climate change knowledge and land management practices** by bridging knowledge and practice, creating links between research, policy and practice. Focusing on stakeholders' priorities and sharing these insights with the wider research team to ensure these contextual dynamics were accounted for in modelling and case-study development.
3 **Focus on developing 'place-based' science** by identifying specific places and sites of common interest for stakeholders using case studies from across five landscapes from the mountains to the sea.
4 **Acknowledge climate variability, uncertainty, and changing risk profiles.** Climate is inherently variable and uncertain and risk profiles are changing, which needs capacity building for decision making under uncertainty, especially deep uncertainty where surprises cannot be ruled out.
5 **Broker new knowledge** externally with stakeholders and internally with other colleagues in the CCII programme by positioning our research at the intersection of data provision for model development and its relevance for stakeholders' decision-making processes.
6 **Work with decision making as object and process** to address the complexities of the social and political processes shaping how climate change is factored into decisions across organisations and landscapes. This means understanding decision making in more depth and detail, including gaining insight into the ways in which it is organised and undertaken.

corporate and private sector business stakeholders that make autonomous/semi-autonomous decisions motivated by individual, social, environmental or economic drivers affecting their interests and also impacting on public interests. Private sector stakeholders included industry and sector bodies; for example, water development agencies, insurers, and banks. The influencer category included representatives from NGOs, land care groups and professional organisations such as IPENZ, NZPI and RMLA. Iwi and hapu contacts were invited to case study workshops; in particular, attending the Lowlands and Marine case study workshops. Private citizens affected by climate change impacts were not included in this research due to resource constraints. However, it is noted that private individuals also have climate change information needs for their private and community decisions in the face of climate change[5].

A total of 52 semi-structured interviews were conducted with individuals from these three groups. All the interviews followed a similar format and lasted from one to two hours. Questions were developed in advance based on a close reading of previous work on climate change and decision making. Interviewees were asked to respond to the following questions:

1. What are the critical climate parameters for your activities?
2. What is your understanding of how decisions are affected by climate change and its effects?
3. What is the nature and timing of your decision landscapes?
4. What factors drive your decision making where climate is also a factor, and how are you influenced by climate change?
5. What climate information do you need to address the effects of a changing climate, in what form and when?

Participants were recruited using e-mail or phone and drawing upon both the researchers' professional networks and snowballing techniques.

Data from multiple interviews was analysed using content analysis and a qualitative data analysis software package (NVivo 10) to identify themes and connections based on the research questions.

Identifying the influences on decision making

To enhance stakeholders' capacity for decision making under uncertainty, both improved modelling of affected systems and insight into how stakeholders use climate change information are required. Knowledge brokering, community of practice techniques and innovative communication methods were used to promote foresight, reduce potential for perverse outcomes through increased awareness and understanding, and improve evidence-based decisions.

Knowledge brokering through landscape-based case studies

To develop stakeholder-relevant insights, RA4 worked closely with RA2 (Understanding pressure points, critical steps and potential responses) to incorporate knowledge co-production into other research activities as well. Purposeful snowball sampling was used to identify key stakeholders for four of the five case study areas: Upland, Lowland, Coastal and Marine, and workshops were held in Tekapo (Upland), Te Puke (Lowland), Hamilton (Coastal) and Wellington (Marine)[6]. The purpose of the workshops was to engage with interested and affected stakeholders, and provide an overview of the research programme as well as the targeted activities specific to each case-study region; for example, land-use or hydrological modelling. The workshops also enabled discussion of potential climate change impacts and their implications in a learning-focused environment. Thus, the focus was on understanding the latest research and one another's views and concerns, rather than negotiating actions. Finally, the group was provided an opportunity to share how they might like to interact with the research over the life of the project.

Local government lies at the nexus of climate change impacts because of its wide-ranging statutory responsibilities for water and land management, which includes considering the effects of climate change. Accordingly, focused workshops were held with regional and district council staff (and some councillors) around a range of council functions and disciplines such as planning and asset management, regional planning, river control, natural hazards and emergency management, coastal planning, pest control and biodiversity management, and the three

[5]The Deep South and Resilience National Science Challenges have projects elaborating citizen needs for climate change information.

[6]Targeted interviews with a small number of stakeholders were conducted in lieu of a workshop for the Alpine case study due to the very specific focus of the research on beech masting events.

waters (water supply, storm water and waste water) transport and utilities.

A total of 102 stakeholders participated in the workshops from public (*n*=65), private (*n*=15) and influencer (*n*=22) categories. All workshop groups – with the exception of Marine – met twice over the course of the research in order to develop the initial insights and contribute to modelling priorities and report back.

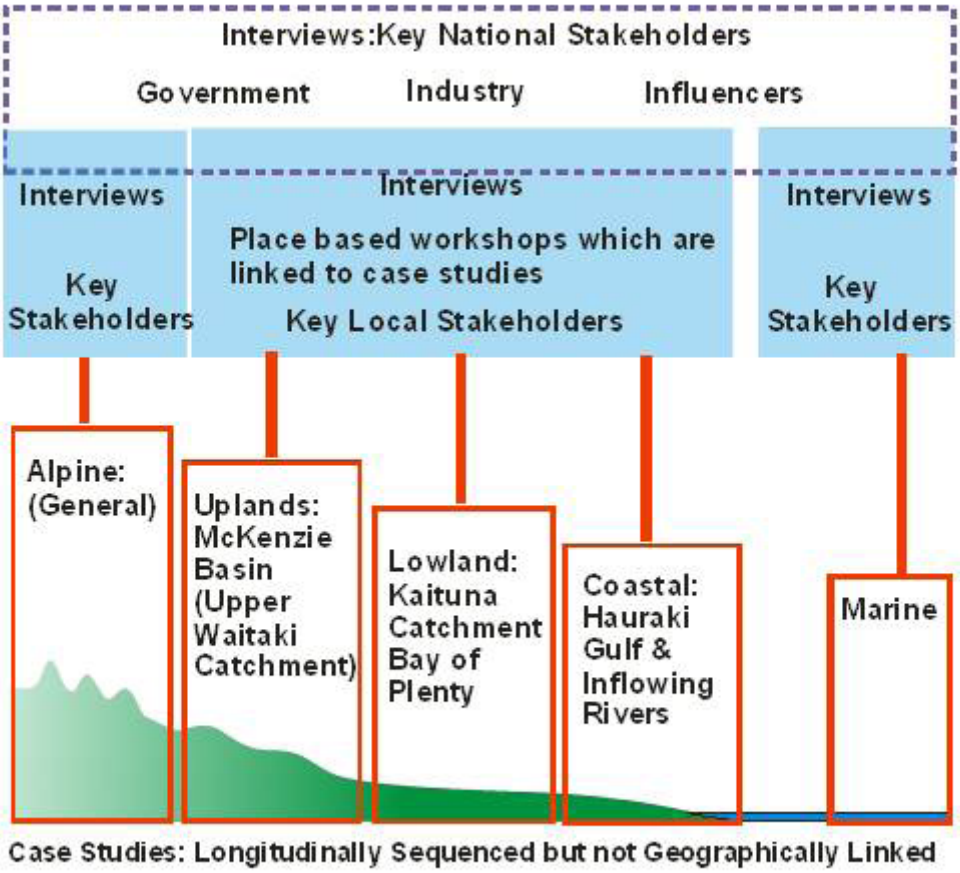


Figure 3: Landscape-based case studies: geographically sequenced but not linked longitudinally.

Co-producing decision-making approaches and resources through a community of practice

In addition to case-study and local government workshops, collaborations with officials actively seeking climate change information for their policy and strategy work were developed. A Community of Practice (CoP) was set up with individuals mandated to make decisions affected by and affecting natural, built and productive systems. The CoP focused on co-development of climate models, as well as resources to inform climate policy procedures.

Through their collective knowledge, experience and networks, the CoP provided advice and guidance to the project team in three key areas:

1) Identifying decisions or policies that included a climate-related component, what information was being sought and how it would be used;
2) Providing guidance on the production of usable climate, ecosystems, built environment and productive systems information to aid decision making, providing input to research questions and commenting on research outputs during the course of the project; and
3) Improving the uptake of research findings, by ensuring the relevance of outputs to real-world decision-making and helping to facilitate the dissemination of new knowledge through their organisation and networks.

Interaction with the CoP was both virtual (via email) and workshops during 2014 and 2015. Participant organisations are listed in Appendix 1.

Visually communicating climate change information

The third part of this objective was to assess the effectiveness of different types of engagement. The primary evaluation tool was an electronic survey administered to CoP participants online. The aim was to determine the extent to which different modes of climate change communication were most effective; for example, maps, graphics, or text.

A survey questionnaire (*n*=16) was developed based on a review of the literature and consisted of six separate sections: information sources; importance of climate for decision making; scale of information provision (i.e., local, regional, national); climate change outputs; climate change framing; and data availability. Respondents (*n*=61 from contact list of 200) were asked to rank their preferences in each section, based on the available options.

Research was conducted in an ethical manner, seeking appropriate permissions and respecting respondents' rights and opinions. Before all interviews and workshops, participants were asked for permission to use a digital recorder. Participants were assured that their comments would not be personally attributed and that they would receive a summary of workshop findings. During all interactions, researchers sought to maintain an open, non-judgmental approach to encourage participants to express themselves fully and respect their rights to express their own opinions. Approval was sought and provided by Victoria University of Wellington Human Ethics Committee (#19675 20 March 2013).

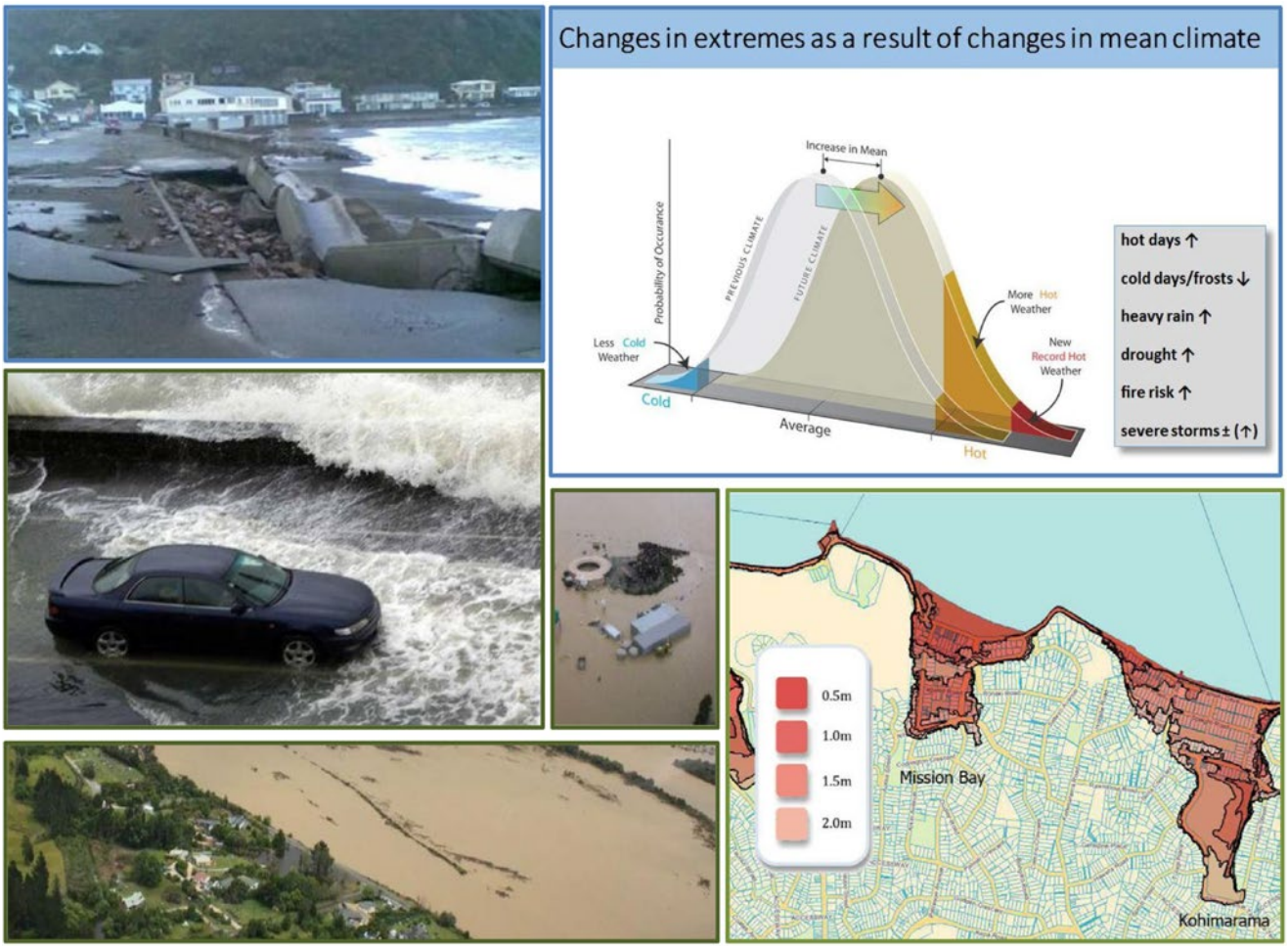


Figure 4: Examples of images used in the survey.

Overview of themes

The iterative analysis of interviews, case study workshop outputs, an online survey, and co-generation of infographics revealed nine main themes: Perceptions of climate change risk; Climate change information; Impacts; Cascades; Decision making; Governance and institutions; Organisational capability and capacity; Barriers; and Critical leverage points. These themes are grouped under four categories: Understanding and information; Effects; Decision-making Implications; and Engaging with Climate Change in Decision Making (Table 2, see also Figure 5). These provide the basis for the Conclusion, Next steps and Recommendations..

Table 2: Analytical themes derived from empirical data

Understanding and information

Perceptions of climate change risk: What climate change risk means for respondents and how they mitigate and cope with such risk, including gaining insight into the ways in which mitigation is organised and undertaken.

Climate change information: Information needed for identifying and managing climate change impacts for use in adaptation decision-making.

Effects

Impacts: The predominant impacts of climate change identified for activities, sectors and stakeholders.

Cascades: strong interlinkages between climate change impacts have the potential to cascade, whereby one impact leads to a chain of events affecting a system or a number of domains.

Decision-making implications

Decision making: The extent to which climate change affects decision making now and in the future, and what information/frames/time frames are used and required by different groups.

Governance and institutions: Governance is the process of regulation, coordination and control that enables or constrains the actions of members of a society. It determines who has power, who makes decisions, how other players are heard and how accountability is rendered. Institutions are sets of rules, decision-making procedures that define social practices, assign roles to actors and guide interactions of between roles (Young, 2002).

Organisational capability and capacity: Who does what, at what level and how. Mechanisms and processes used to manage climate change risks; self-efficacy, the ability to access and mobilise resources and negotiate.

Engaging with climate change in decision making

Barriers: Impediments to integrating climate change into decision making and policy.

Critical leverage points: Opportunities that could enable greater consideration of climate change impacts on functions and activities.

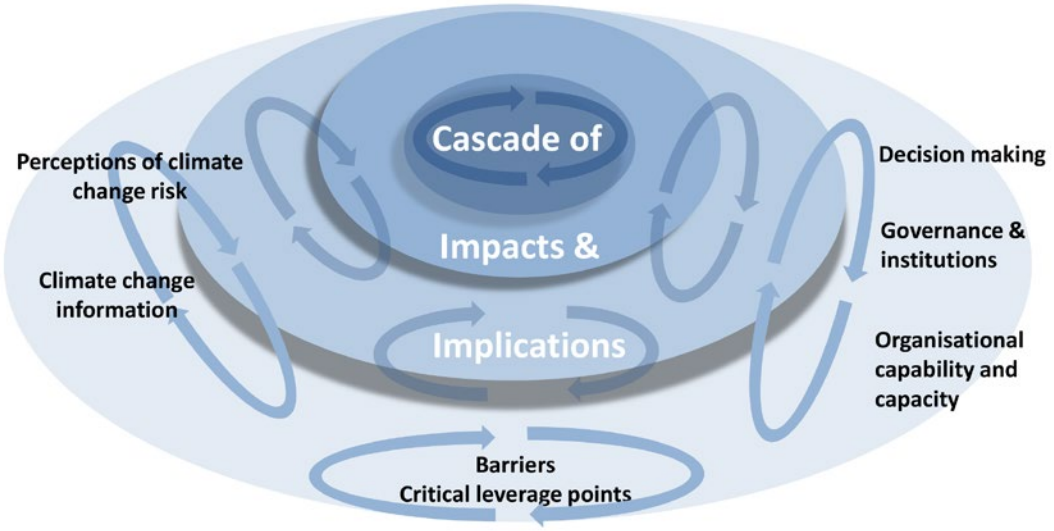


Figure 5: Themes and their interactions.

UNDERSTANDING AND INFORMATION

The following perceptions are based on data collected and analysed over a four-year period to September 2016. During that time there was some evidence of changing perceptions about climate risks and these are noted below. However, this change is by no means embedded in decision practice nor is it uniformly applied even where decision practice is changing.

Perceptions of climate change risk

Risk is defined (IPCC, 2014) as the interaction between the hazard and its likelihood, exposure of human and natural systems to the hazard, and their vulnerability (Figure 6).

Risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems. Changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability (IPCC, 2014).

Respondents discussed the key risks they currently manage and were prompted to consider emerging climate-related risks. In most cases, climate change impacts would exacerbate current risks, but some respondents could also foresee new risks emerging.

Key risks

Vulnerabilities arising through natural systems were the starting point for the private sector, since many saw these as dominating in their domain (global-market risk) or saw climate change issues implicitly captured within existing risk considerations.

For both kiwifruit operators and foresters, pest and disease management were the most significant risks, which they acknowledged may become more prevalent under different climate scenarios.

> *So before Psa,[7] if you talked to growers, they would have said the [life of a] kiwifruit orchard is 30 years plus, not too dissimilar to a forest, but post Psa people are talking about a lot shorter [time frame].* ***[Kiwifruit industry respondent]***

The impact of pests on forest health, habitat loss and unstable land were the primary risks for foresters.

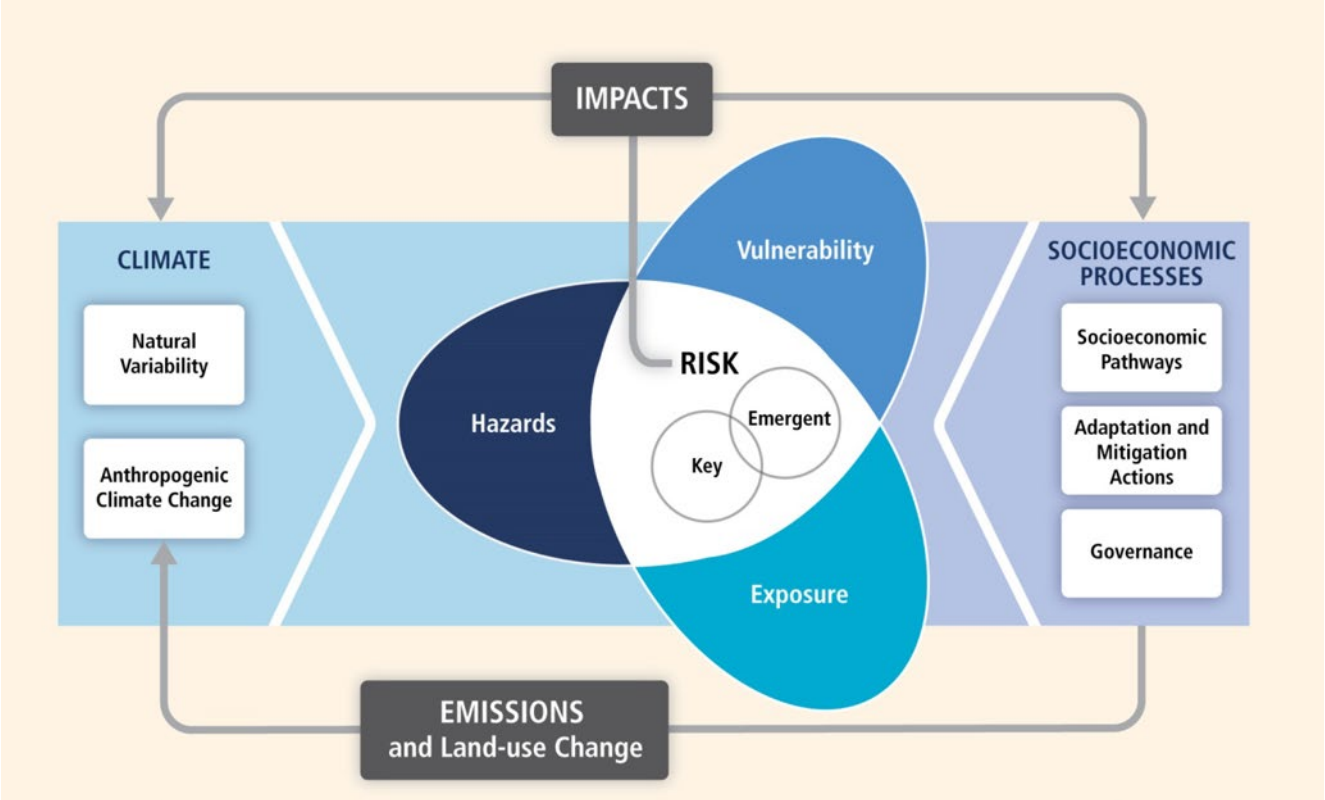


Figure 6: Illustration of the core concepts of the IPCC WGII AR5. (IPCC, 2014)

[7]Pseudomonas syringae pv. actinidiae (Psa) is a bacteria that can result in the death of kiwifruit vines. It was first discovered in New Zealand in November 2010 and rapidly caused widespread and severe impacts to New Zealand's kiwifruit industry.

We're now looking to deploy seed lots with good Dothistroma[8] resistance ratings right across our estate to some extent to cater to the uncertainty that change in weather, if it is occurring, could increase the risk of Dothistroma in parts of our estate where it's not currently a problem or could increase the susceptibility to other fungal infections.
[Forestry industry respondent]

Market access risk through not meeting specific regulations or product specifications also dominated. Foresters' risk concerns centred on forest safety issues, such as managing recreational use between hunters and other members of the general public, potential arson attacks and vandalism. Foresters' shareholder risk was a key business risk; an expectation to return dividends drove investment activities.

The banking sector viewed environmental risks on a case-by-case basis when determining lending decisions; for example:

If there is a property against which you're securing a loan that has particular risk characteristics like a farm on a flood plain that experiences big floods periodically every six to seven years, you take that into account in your lending decision…But its situations specific as opposed to being generic.
[Banking sector respondent]

In the case of coastal properties vulnerable to coastal erosion and tide surges, the banking sector expected a gradual reduction in the extent to which they could lend against those properties and/or they will also require a higher level of equity from the borrower to issue a loan or they will likely apply a penalty interest rate. By way of example, banks are beginning to take a greater interest in water-related and nutrient-leaching issues in the agricultural sector when managing their lending portfolios. While the dairy sector has responded by focusing on nitrogen outputs from their activities and have instituted nitrogen budgeting with water metering being developed with suppliers, it appears that further pressure will come from banks for risks that are exacerbated by changing climate parameters, such as temperature increases and the effects of flooding and sea-level rise.

Many of these risks will be affected by changing-climate risk profiles. However, respondents often did not initially see the climate connection between these types of impacts until possible links were suggested. There is also a predominant near-term and experienced risk focus in their perceptions of the risks they face that will become clearer as climate-related risks are discussed.

Emerging climate-related risks

Significant economic risks associated with climate change were identified across several sectors. Climate-related changes to the distribution and abundance of pests and diseases poses a threat to the New Zealand cut flower industry, guava and feijoa fruit growing, and the honey industry.

We started looking at the ecosystem services associated with growing kiwifruit, and pollination is an important aspect, and the impacts of different climate change scenarios on the beekeeping industry.
[Kiwifruit industry respondent]

One specific example mentioned was the varroa mite threat to bee keeping and honey production. Reduced resilience of the system under a changing climate was raised, for example, as a consequence of reducing genetic diversity of mānuka as selective breeding of the plants takes place, which can increase vulnerability to pests and diseases of species within the system.

The forest sector is more exposed than some sectors to climate-related risks due to the long production-cycle; for example, drought, extreme rainfall, and wind events increase fire risk and damage to the forest crop.

Kiwifruit operators viewed climate change risk firmly though the lens of market risk; i.e. a climate risk is worth considering if it impacts on market conditions and ultimately sales of kiwifruit. Climate risk was more directly considered in relation to fruit breeding and planting strategy and planning. Variety selection is driven by factors associated with winter chilling and the post-harvest handling of the crop. Operators were considering the types of cooling systems needed to remove field heat and the additional energy required as a result of projected changes in climate.

Regional councillor respondents saw their risks determined by the statutory framework within which they operate — the risk-based approach to natural hazards that also captures changing-climate risk through the Resource Management Act (RMA) and by the insurance industry.

[8]Dothistroma pini is a pine needle blight that affects pine trees aged 1-15 years.

The insurance companies are going through New Zealand under the Official Information Act and requesting flood maps and hazard maps on everything volcanic, floods, anything at all because they're building their databases and making a risk-based approach to the way they do insurance now.
[Regional councillor respondent]

Proactive risk management from insurance companies also factors in the climate change-driven impacts associated with flooding and sea-level rise. For councils, there are tensions between proposals to develop high-density residential and commercial land, and restricting such developments due to the risk of coastal erosion, sea-level rise, and tsunami risk, which they are required to reduce, avoid or mitigate. The risk of tsunami was an emerging risk raised by a wetland trust.

Resilience through interconnectedness

Disruption to supply of products or services was frequently expressed as a market risk related to climate change. Kiwifruit operators are working with central government agencies, for example, the Ministry for Primary Industries (MPI), to assess the resilience of their growing systems and transport logistics. Impacts of storm surge and/or sea-level rise on transport infrastructure have been considered to determine the potential impacts on network infrastructure and on sector logistics. This has enabled the sector to consider delays for kiwifruit getting to customers domestically and internationally. This planning activated thinking about landscape-scale impacts and value-chain interconnectivities. Furthermore, pressure from large retail chains and shareholders is driving greater transparency about the vulnerability of fruit supply to extreme weather events.

Shareholders in the retail companies are starting to ask questions of CEOs, we're starting to see a push down the chain seeking greater transparency of the level of exposure to extreme events.
[Kiwifruit industry respondent]

Regional councils are incorporating adaptive catchment-management practices that consider interconnectivities. Conservation management in New Zealand similarly recognises the challenges and benefits of a systems-thinking approach when it comes to risk management by mainstreaming "long-term multiple issues, including climate change", into management priorities. How this might work in practice for climate change is still a "work in progress".

Recognising reactive risk management and overcoming uncertainty

Some primary sector respondents indicated that they are not going to take a proactive approach toward managing climate risks. Their inclination is to wait for the science to provide solutions that they can incorporate into their management practices. Farmers' representatives, however, took the long view:

Some people might still resent expectations laid upon them, but they do generally accept that it's the way the world's moved. And if you want to continue to be involved, you have to adapt and take recognition of those things.
[Farming interest respondent]

A number of foresters suggested that from a budget perspective it is often not feasible to manage for risk by looking at the future impacts of a project. For them, the best approach is to monitor existing impacts and process and combine these with historical records to create risk management plans. However, wind risk was an exception to this rule, since it is viewed as potentially costly to the forestry stock. Foresters called for more certainty about climate impact projections from the scientific community to enable better management decisions for addressing extreme weather events. There was one innovation to build plant stock that is resistant to expected diseases that will become more prevalent with climate change (Box 1).

Box 1. Strategic adaptation to climate change - Radiata breeding to improve resilience

Climate change is influencing the genetic deployment of more resistant radiata pines to anticipate climate-related changes in disease exposure of the forest estate. Breeding is currently done with the preferred parents being used in cross-breeding programmes that produce the seeds for the eventually planted trees. The breeding programme selects parents that improve growth, wood properties and disease resistance. There is current susceptibility within the forestry estate to the fungus *Dothistroma pini*, so parents are selected that have improved resistance to that pathogen. The resultant genetic stock is deployed to areas that do not have *Dothistroma*, in the expectation that the adaptation to *Dothistroma* will have cross-resistance to other diseases, such as *Cyclaneusma* and red needle cast (RNC), that are likely to become more prevalent as the climate changes.

In the agricultural sector, uncertainty in the magnitude of climate change makes some farmers hesitant to actively consider climate change in their risk management strategies. Framing the discussion around management of extremes was seen as a productive approach. For example, when discussing drought management or paddock management to reduce nitrogen or topsoil run-off after heavy precipitation events, they contextualised climate change risk by highlighting that these events will become more extreme under modelled future-climate scenarios. In the forestry sector, some forest managers are moving to more conservative stocking regimes to mitigate against loss from extreme wind events. However, the majority of forestry managers still consider global-market driven supply and demand factors to be much higher on their list of concerns.

Uncertainty of projected future climate conditions and a perceived prohibitive cost of managing for climate change risk was viewed in the farming sector as two interlinked and leading reasons why many farmers act in a reactive manner to climate risks. Despite drought conditions increasing in frequency and magnitude in some areas across New Zealand, farmers are hesitant to invest when the costs of setting up (procedural, political, environmental) an irrigation system or drilling an additional borehole on their property are weighed.

On the other hand, a different example highlights the limitations of reactive risk management in the case of some low-lying flood protection schemes (e.g. where there is an earth stop bank in place for flood protection, the width of the base limits the height to which the structure can be raised). This has initiated consideration of a managed realignment project that allows a range of structural and non-structural ideas to be considered and that will avoid some of the limitations associated with reactive management. Such an approach was enabling the community to "widen out their thinking" (Regional council staff respondent) and not shut down options before being fully considered.

> *Managed retreat is definitely on the table. Yes to all of those. We've got structural and non-structural ideas, you know, planting the whole upper catchment in forestry, yep, those sorts of things. We will have a bit of a look at those and maybe shortlist a few, we'll have a workshop and we'll probably come down to about three or five combinations of solutions that they will then investigate further.*
> ***[Regional council staff respondent]***

In summary, private sector respondents discussed climate risks in the context of wider market-related risks, some have considered the climate risks to their sector; others have not, while others intend not doing so until science delivers management solutions to enable adaptation of their practices. Respondents often did not initially see the climate change connection with existing risks they face, but when asked about these further, were able to visualise and convey the value-chain implications for their sector.

Public sector agencies are driven primarily by the statutory mandates within which they operate, which are motivated by sustainable management of natural resources, conservation, and by risk management (hazards and climate change) responsibilities. This motivates more systems and interconnected thinking, which is starting to factor in climate-related risks, such as how they will change in the future and the impact on decision making and operations; for example, using dynamic adaptive pathways planning for evaluation of flood risk management options in

decision making (Greater Wellington Regional Council, 2015).

The influencer groups have a mixture of the private and public sector perceptions of climate-related risks, depending on which domain they operate within. Some are actively making connections, whilst others with the ability to work within their sectors have not yet taken up the issue.

All groups had a predominant focus on the near-term and experienced risks whether business, statutory or specifically motivated. This is consistent with research on motivations for acting (Kousky, Pratt, & Zeckhauser, 2010; Tversky & Kahneman, 1974). To better understand how this might change, we also sought to understand the impacts that were perceived to affect the sectors.

Climate Change Information

Different stakeholders have different types of information needs. As these local government respondents put it:

We need scenario information that integrates social, economic and climate risk. This means that for planning, good non-climate factors are needed for scenarios, as well as climate change information. New Zealand doesn't have a set of national scenarios for non-climate outcomes.

Vulnerability information is needed that highlights the social groups affected by change impacts

We don't have good data on assets at risk. We need to assess which assets are affected and their social and cultural value. And what values will be lost as a result of climate change impacts; and

Response to climate change is needed beyond the formal plans. Plans don't pick up the opportunities over time to reduce vulnerability and improve resilience

Understanding climate change information requirements and gaps can be described by the following typology:

1) Information that enhances **understanding of future climate change risks** for the full range of decision-relevant variables, including temperature, precipitation, wind and changes in their distribution (frequency of occurrence and magnitude), and sea-level rise.

2) Information about **implications of** climate change that are relevant to stakeholder interests; for example, productivity, habitat, or snow loss; or decreased precipitation over defined periods of time or times in a year.

3) Information needed for **adaptation decision-making** that accounts for changing risk profiles over time, available adaptation options, community-engagement frameworks and methods, and cost-benefit analysis methods for changing risk profiles.

Risk is a function of likelihood and impact (consequence), as well as a function of time and scale (Figure 7). By including time and scale, uncertain future outcomes can be considered more closely in decision-making processes to explore the implications of climate change impacts. These impacts can be assessed qualitatively according to the degree of confidence in the information, quantitatively, and according to decision-relevant factors specific to the domain of interest. Vulnerability assessments of an activity or the exposure and sensitivity of a sector to a climate stressor can enable decision-relevant impacts to be identified. Adaptive capacity determines the degree to which the impact can be managed, and is determined by available information, access to resources, and social and economic conditions, for example.

Figure 7: Risk as a product of likelihood and impact, time and scale.

Source: National Academy of Sciences. Characterizing Risk in Climate Change Assessments: Proceedings of a Workshop for the U.S. Global Change Research Program (National Academy of Sciences, 2016).

Issues relating to time frames and spatial scales are central to understanding and making decisions regarding climate change impacts: Will the planned activity last a short time or a long time? Will it set in train more of the same sort of activities or set up dependencies on services for it to be sustained, and thus contribute to 'lock-in' and path dependency?

In New Zealand, the information available as one advances from one to three through the typology above becomes less well defined. This means that decision makers are currently working from a limited information base and making decisions that could be difficult to adjust in future as the risk profiles change outside the range of current experience. This suggests that decision-relevant information needs to be better characterised and tools adopted that can address the time and change elements affecting today's decisions that persist into the future. Some examples are shown in Appendix 1.

Three gaps were identified: information gaps in understanding climate change risks; gaps in qualitative and quantitative understanding of impacts stakeholders were interested in; and gaps in information that restrict the ability of stakeholders to take adaptive actions.

Information gaps in understanding of climate change risks

These gaps relate to an awareness of whether climate change could impose a risk or not; key gaps in understanding the impacts; adaptation research; and that few links have been made between natural and human system responses.

Public Sector

The "Battle for the Birds" project was initiated in recognition of climate effects on pest management in indigenous forests associated with beech masting[9], Research in the Alpine Case Study (RA2) using the DELTA-T model showed that climate change may lead to larger beech masting events, resulting in significant population growth of pest species (e.g., mice and rats). Managing future pest outbreaks would be costly. Long-term monitoring of environmental variables then was identified as a critical gap for decision making about such climate change impacts to move away from short-term, reactive, "ambulance at the bottom of the cliff" funding.

There was also relatively limited understanding highlighted of the inter-dependencies between climate parameters, plants, insects (e.g., honey bees), fungi and soils, and systems. This is a significant research gap due to New Zealand's high level of endemism, the large number of threatened and endangered species, and the dependence of our tourism industry on a healthy indigenous flora and fauna.

Local government also highlighted difficulties associated with protecting biodiversity and managing biosecurity in the face of climate change. Plant pest surveillance is expensive and the social costs of pest management schemes are often difficult to value. As a result, pest management funding is often tied to land use: agriculture drives agricultural pest management and if land use changes, pest management will often not be funded. Some respondents suggested that the local community could provide resources for co-management of pests; however, there are capability and capacity limits for such initiatives. Long-term monitoring needs of biodiversity protection and pest management do not often fit with funding programme timelines.

One respondent said that the effectiveness of biodiversity protection was limited by focusing on existing threats under current climate conditions at the expense of future threats to habitat.

> *We have long-term ten-year planning and we have to put some measurable long-term goals that we are working towards. As funding is set up in three-year cycles this constrains what we can do.*
> ***[District council pest manager respondent]***

Genetic hybridisation of mānuka plant stock was also identified as a key factor in reducing the resilience of mānuka plant stock to pests and disease. Some New Zealand nurseries, for example, are creating improved cultivars using Northland stock to plant all around the country. However, the implications of this change in practice are poorly understood. The extent to which bee populations may host and transfer plant diseases more readily under different climatic conditions and the vulnerability of hybridised stock is not yet known.

The impacts of warmer temperatures on mangrove growth and distribution are also not well understood. There are indications that mangrove distribution may expand south and impact on local environments. The expansion of mangroves into marginal salt marsh habitats – and subsequent drying out – may have impacts on bird and invertebrate communities in these areas, but more detailed understanding of these systems and their interactions is required.

Our analysis also showed that climate change adaptation research in New Zealand is highly fragmented, poorly coordinated between several research programmes, and disproportionately

[9]The irregular seeding of millions of hectares of beech trees that occurs once every 10 to 15 years, resulting in an explosion of mice and rat numbers affecting wildlife, is driven by changes in temperature and specific weather events.

focused on the primary sector, diminishing its utility for decision making across other exposed public and private sector agencies.

Using adaptive pathways planning tools and practice is an example that has emerged from research embedded with science and practice. However, such an integrated approach that links practice needs with regionally detailed hydrology and sea-level rise projections was identified as a research need. Such integrated research was identified as better able to inform risk and vulnerabilities assessments, their economic and social evaluation for developing adaptation plans, and for better understanding of policy enablers for their implementation. Two physical science gaps that were identified in this context included a better understanding of the interaction between sea-level rise and groundwater flooding, and the effects of salt-water intrusion on ecosystems. While a gap was also identified around the governance and policy tools that can enable retreat from the coast as sea levels rise.

Some councils find it difficult to handle scenarios in their decision-making processes, while others see that they must, to adequately consider the uncertainties associated with the frequency and magnitude of certain impacts. Wider use of scenarios was identified as a useful way of testing different adaptation options.

Some councils pointed towards a lack of detailed climate-impact data that could be used in preparing their latest district plans. For example, detailed wind maps and precipitation data at a scale they wanted for identifying climate change impacts. They also suggested that a national LiDAR (high resolution digital terrain map) database would assist in this context.

The three waters (water supply, waste water, and storm water) and road infrastructure comprise "more than $100 billion of community assets" (Office of the Auditor-General, 2014) – a majority of local government services. This is particularly significant when matched with respondents who suggested that current infrastructure does not adequately meet today's need for water supplies and flood risk management. Future demands aside, a changing climate will only exacerbate this 'adaptation deficit'.

Tied to these gaps was a call for greater resources to be made available to educate communities on climate change impacts and implications at a local scale. As one District Council respondent said:

> *You're trying to genuinely alert people to an issue that needs to be dealt with at a societal level ... I think that's when people will really start to look at their own practices.*
> ***[District council staff respondent]***

Private Sector

The tourist industry wanted more detailed information for planning purposes on potential climate change impacts across the country, and on the impact on tourism activities.

The electricity sector appreciated that projections of future (summer) rainfall changes are difficult to determine, but expressed concern that existing uncertainty ranges make planning difficult. For them, a more tightly defined range would be helpful for decision making. They also called for both dynamic and statistical downscaling of global circulation model outputs to local catchment and river scale. Public sector respondents also called for tighter ranges, highlighting a gap in understanding the significance of the tail of the rainfall and sea-level rise distributions, which are where the greatest impact on sectors will eventually occur from sea-level rise.

The insurance industry called for more high resolution data for areas prone to flooding and sea-level rise. Acknowledging that insurance is a 'blunt instrument', insurers indicated there is an industry-wide effort to gather more data on potential hazards and related losses in order to rate risk more specifically as a corollary to raising community awareness and eventually reducing vulnerability.

The kiwifruit industry identified gaps in understanding its inter-connectedness to a range of ecosystem services; landscape-scale impacts such as erosion, runoff, harbour dredging and irrigation; and international market risk associated with climate change impacts on kiwifruit production. Producers also referred to the increasing importance of understanding the resilience of offshore growers to extreme events, pests and diseases. Impacts on the overseas kiwifruit crop can change global supply of and demand for kiwifruit and this, in turn, impacts on New Zealand-based growers. A greater understanding and knowledge of soil carbon for managing orchard droughts, and the role of water storage was also indicated as an area of increasing research interest.

Climate change is expected to impact on the inputs/drivers of primary production such as grass

production, crop stress, and water availability, and on the frequency of storm events. Information on these and adaptive practices will be critical.

The forestry sector called for more comprehensive data on tree resistance to diseases such as *Dothistroma* needle-blight as climate changes. There is insufficient information for assessing vulnerability to other diseases, and their potential impacts. More regional-level climate data for temperature, precipitation and wind speed will assist in this understanding.

Influencers

The impact of climate change on New Zealand's fresh-water fishing resource was identified by national-level NGOs. For example, fish spawning streams narrower than one metre and shallower that 30cm are currently not covered under the clean streams accord. This has the potential to leave these habitats vulnerable to the impacts of climate change and poor dairying practices. The value of raising public awareness on climate change issues was emphasised.

Information gaps in implications for sectors

Public sector

The local government sector, with its diverse responsibilities, is at the frontline of climate change impacts. This creates many complexities for managing 'common pool' resources, especially where they intersect with private interest: a 'land and water nexus'. This is increasing community tensions for issues like coastal hazards planning, water resource allocation, regional development, and the provision of services.

Understanding the implications of climate change on service delivery was referred to by a number of local government respondents. For example, climate change is projected to change the seasonality of water demand, the quantities of demand from changes in land use (irrigated dairying), and urban demand for water. Both urban demand and demand from changes in land use could significantly increase water demand from the same resource in areas such as Canterbury, for example.

Information on the overall impacts of climate change on water quality has become a gap for those managing stressed water resources in New Zealand. The interaction between changes in precipitation and water quality was identified as a gap in knowledge.

Understanding changes to population distributions of pests, diseases, and pathogens from climate change on land uses and the natural environment is a gap in knowledge that needs to be filled for effective decisions over time. Examples cited included management of indigenous forest remnants, wetlands and coastal habitats.

Private sector

Frameworks for effective action that could identify impacts and the implications were called for by the private sectors, along with greater specificity of information geographically.

How Information is being used to adapt to climate change

Public Sector

Local government implements planning requirements on floor height, on storm-water mitigation measures and set back lines for location of new urban developments, and vulnerable road protection using the National Guidance on rainfall events and sea-level rise.

> *Looking at what we might put in the District Plan in terms of rules or additional storm-water mitigation because of climate change, we have urban areas that are in low lying coastal locations that are prone to flooding already. So, what we've done is we've undertaken plan changes so that going forward new dwellings in those locations will have to be at a habitable floor level that is above the 1-in-50 flood level.*
> ***[District council respondent]***

Regional councils use climate scenarios to evaluate the costs and benefits of different flood protection measures and more recently to incorporate climate change as an exacerbator of hazard risk using adaptive pathways planning.

National park management plans are beginning to address the impact of climate change on hazard risks affecting use of national parks.

Other parts of the public sector at a national level have undertaken climate change impacts studies (Gardiner et al., 2009), but this has not feed through to consideration of the change in risk profiles for planning of long-term assets. The requirement for long-term infrastructure plans now in the Local Government Act (2014 Amendment) may change this.

One regional council has initiated a River Scheme Sustainability Project (RSS) for mapping out the

long-term vision of their community. The project sets out a long-term flood risk management strategy that acknowledges legacy issues from past planning decisions and the fact that "we can't keep building stop banks forever".

Tools used by the public sector include tools for public consultation processes and to convey complex information in simple ways; for example, using interactive flood-management tools and online survey tools to explore and understand the impacts of flooding. Western Bay of Plenty District Council, for example, used a round-the-table online discussion forum with the Waihi Beach community in the run up to their long-term plan review in 2015 (see Box 10); while Tasman District Council used animated modelling outputs and difference maps when planning for flood risk reduction in the Takaka community (see Box 2).

Box 2. Use of Information for community engagement: Takaka River Flood Hazard Project: Tasman District Council (TDC)

The Takaka township is located on the flood plain of the lower Takaka River in Golden Bay, Tasman District. Climate change projections identified that the present day 200-year Average Recurrence Interval (ARI)-sized event could become a 100-year ARI by the year 2090. The township has continued to develop over the last three decades, and both river and landform changes have altered localised flood risk. The following steps were taken to investigate the risk and to engage with the community prior to examining the response options. The council commissioned modelling of the flood hazard for events up to the 200-year ARI using LIDAR contour data. This confirmed a moderate to high flood hazard for some parts of the township and medium to very high hazard for much of the surrounding rural land. Eight risk reduction options where suggested for the township, including zoning and building controls and flood flow path protection. Modelling (DHI MIKE 21) and waterRIDE ™ FLOOD Manager display software were used for preliminary investigations of several of these options, including structural protection methods and river gravel management. Static maps for peak flood depth and velocity, difference mapping (primarily used for scenario comparison) and depth x velocity hazard maps, as well as animations of modelled floods were created.

The council decided to use the 200-year ARI as a proxy for including climate change within hazard assessments to inform long-term planning decisions. The council also excluded the effects of an existing structural defence, effectively utilising a worst-case scenario.

The modelling results were communicated to the local community at a public open day, through local media, and on the council's website with the aim of initiating discussion on the hazard and the potential responses to the risk. Static poster displays and Powerpoint presentations were used with both flood maps and animations to visually communicate the hazard and outline the potential response scenarios. A terminology guide was provided, including a short explanation of Annual Exceedance Probability (AEP) and Average Recurrence Interval (ARI), and the relationship between the two, to highlight that multiple extreme events could still occur close together. A summary was also provided of the assessment of flood risk with respect to asset management and development planning (modified from *Preparing for future flooding: A guide for local government in New Zealand, MfE, 2010*). The flood risk was defined using various methods including ARI, AEP and expressions of chance: for example, there is around a 1-in-4 chance of a 100-year ARI-sized event occurring in the next 30 years or a 63% chance that an asset with a 100-year life span will experience a 100-year ARI event.

Private Sector

Electricity generators, transmission, and supply companies use wind, rainfall, lake, and river-flow information to monitor trends that might impair generation capacity and supply system integrity. Information is used to 'mute' flood peaks in the system, predict extreme events, manage lake levels to accommodate extra flows and avoid flood events that could cause infrastructure damage. Climate change information is used to reassess probable maximum floods to ensure that critical infrastructure is protected from changing risk profiles. Such information comes primarily from the MetService and the National Institute of Water and Atmospheric Research (NIWA) in combination with their own in-house research team and funded post-graduate projects that couple the climate data with economic forecasting and demand management modelling.

The insurance sector has in the past worked with local councils and communities in the Thames-Coromandel District to reduce their risk exposure by raising awareness of coastal and inland flooding and on actions that could reduce the impacts of such flooding.

There were sectors that still use historical and current climate conditions to manage their future risk without considering changing climate risk profiles. The forestry sector highlighted their reliance on historical data in their planning processes. They suggested that from a budget perspective it is often not feasible to manage for risk by looking at projected future impacts. For them, the best approach is to monitor existing impacts and process, and combine these with historical records to create management plans. Foresters also keep a close eye on precipitation levels and projected seasonal forecasts to manage their plantations. The quote below elaborates on their approach:

> *It's all about trying to build a pattern of where we're getting to and what's changing, and what's the cause and effect of these changes, and having valid information there to actually use for forward planning.* ***[Forestry sector respondent]***

Projected ranges in climate and sea-level rise data are reported as making it hard to attribute the variation in climate to climate change or natural variability. These respondents needed to be convinced of the difference in long-term trends in climate to identify the differences from climatic fluctuations. This highlighted a need for greater understanding of how decisions could be made under uncertain conditions without definitive numbers and proof of cause and effect relationships.

The primary sector uses climate change information such as scenarios or specific catchment scale information to evaluate options for both strategic and transformational adaptation (See Box 3). These are motivated primarily in response to current risk management requirements, but have co-benefits for climate change adaptation. Examples of adaptations include changes in infrastructure in forestry road engineering to minimise erosion and debris flows during peak flows; breeding programmes in cropping and forestry to develop specific biological resilience to diseases; and changes in locations of forestry species planting in response to damage from snow and disease.

Box 3. Current use of climate change information in the kiwifruit industry

Since the early 1990s, the kiwifruit industry has gained insights into the impact on crop production from climate change from scientific outputs. The CLIMPACTS model developed at the University of Waikato was used to examine the impacts of climate change on fruit growth and development using a range of climate change scenarios. Impacts such as changes in pests, biosecurity risk, and weed development were identified using more-specific regionally-downscaled climate change scenarios. More recent work has examined the likelihood and impact of extreme events, such as flooding and drought on their crop. Thus, producers have been able to factor in these projected impacts when selecting crop varieties. For example, gold variety fruit requires less winter chilling than the green variety. When examining the ecosystem services associated with growing kiwifruit they identified the importance of pollination, and thus the beekeeping industry. The role of soil, by managing soil carbon to increase orchard resilience to drought events and to maximise water storage, has also been examined.

Decision tools are being used by a number of sectors. The kiwifruit producers provide a decision support tool to growers called CropIRLog that enables exploration of irrigation strategies to optimise particular soil types and factor in historical or forecast meteorological data to aid their decision making. Foresters rely on Geographic Information Systems (GIS) to help with their information management needs. GIS can house a wide range of spatially referenced environmental

data that can be queried, analysed, and updated. A tool known as Atlas Forest Scheduler is used by the forestry industry to manage plantations.

Influencers

A good example of innovative climate change-relevant information generation is by the Lakes Water Quality Society, which enlisted their regional council to fund scientific expertise to help solve local water quality management issues (Box 12).

In Northland, New Zealand Landcare Trust completed a project focused on adaptation and mitigation to climate change in farming communities. With additional support from central government, this led to a rural recovery programme which supported farmers during and after flooding and drought events. Their involvement in the programme allowed them to significantly increase their database of farmers and could potentially focus on long-term planning instead of solely recovery from climate events (Box 4).

A survey of information formats

Visually communicating climate information

All participants of the COP were invited to take part in a survey assessing current and potential climate change-communication approaches; more specifically, the efficacy of visualisation techniques. Over 200 people were contacted with 61 surveys completed. The majority of survey respondents were from local and regional government bodies (48 responses). Table 3 (below) categorises the responses. Sixteeen questions were asked in total (Summary of findings in Table 4).

Box 4 New Zealand Landcare Trust: An organisation linking knowledge and action

New Zealand Landcare Trust is an independent, apolitical organisation which operates between science organisations and rural landowners as a boundary organisation. They facilitate dialogue and the exchange of information which enables rural land owners to act in a way that is both environmentally responsible and maintains their livelihoods. Guided by the principle of "Sustainable land management through community involvement", change is achieved through working with Landcare Groups, the community, environmental groups or individual farmers. The Trust's work is currently focused on water with a focus on catchment management and farming within nutrient limits. Climate change adaptation or mitigation is viewed as a potential secondary benefit from changes in land management practices designed to achieve water quality goals.

...to integrate land and water management with biodiversity and climate change adaptation. So, if you can do it that way, it's really about optimising the farming system for production and environmental sustainability which can incorporate this adaptation component.
[Trust advisor]

The Trust is an important linking organisation, which could assist with articulating landowner needs. The re-telling of "good stories" and framing the problem so change to adaptive practices that are robust across a range of climate outcomes are perceived as beneficial.

Table 3: Survey response categories.

#	Answer		Response	%
1	Local or Regional Government		48	79%
2	Private Sector Organisation		10	16%
3	Non-Government Organisation or Community Group		3	5%
	Total		61	100%

Table 4: Summary findings of the survey.

Information Sources

(order of preference) Colleagues in-house, the internet, experts at research institutes, and colleagues in other communities were ranked as the information sources typically consulted by the survey respondents to obtain the data and information needed for their work.

Importance of climate impact for decision making

(rank ordered) Surface flooding and river flooding, coastal erosion and storm surges, and heavy downpours were seen as the most important climate impacts for decision making.

Information Scale

(order of preference) Regional, catchment, and management area specific were seen as the most useful scales for planning for adaptation to climate change.

Usefulness of climate change products/outputs in decision making

(order of preference) Maps, infographics (information graphics), charts and graphs, and short written summaries were considered the most useful from a range of climate change products/outputs for decision-making purposes.

Framing of climate change

54 % of respondents agreed and 30% strongly agreed that framing climate change in terms of extreme events is useful for decision making.

Where and how to make data available

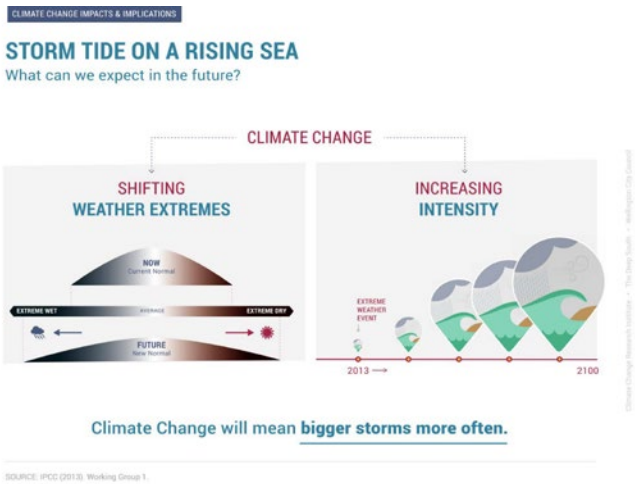
32% of respondents would strongly prefer and 31% would very strongly prefer for visual climate information to be provided through an internet resource housed with NIWA, MfE, or another appropriate agency.

Drawing on the outputs from the online survey, a collaboration was established between the New Zealand Climate Change Research Institute, Wellington City Council (WCC), and the Greater Wellington Regional Council (GWRC), with assistance from a graphic design professional to generate information graphics (infographics) through a co-generated process, to provide useful communication tools about climate change impacts and implications for their use.

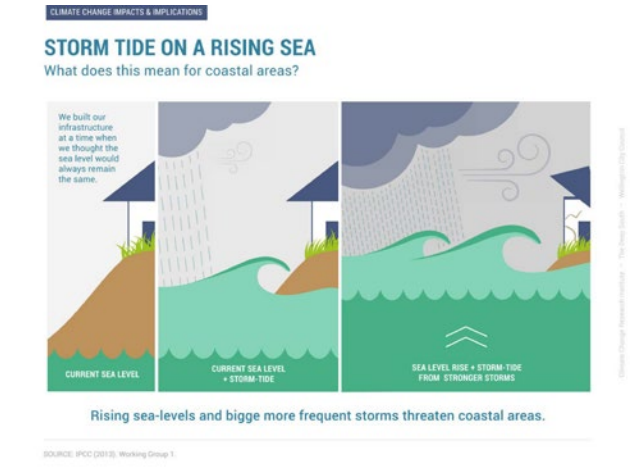
In line with the results of the online survey, sea-level rise, coastal erosion and inland urban flooding were identified as the two most pressing concerns for their councils and to be targeted at other council staff focusing on extreme events, drawing from the lived experiences of communities.

The "Storm Tide on a Rising Sea" infographics are shown below. Figure 8 A frames the lived experience of the 2013 Wellington winter storm. Figure 8 B explains the climate change driven shifting weather extremes and the increasing intensity of storm events. Figure 8 C unpacks the components of a "Storm Tide on a Rising Sea". Figure 8 D highlights some of the likely impacts in Wellington on property, infrastructure and the environment, due to a combination of storm tides and sea level rise.

A



B



C

D

Figure 8: Storm Tide on a Rising Sea infographics.

EFFECTS

Impacts

Climate change impacts are the effects a climate-related driver may have on a system or its activities (Figure 9). Impacts generate implications for different sectors and organisations.

In interviews and workshops, respondents were asked about climate change impacts currently experienced or expected to impact their activities and interests. The following section discusses these impacts and how they are currently being considered by stakeholders.

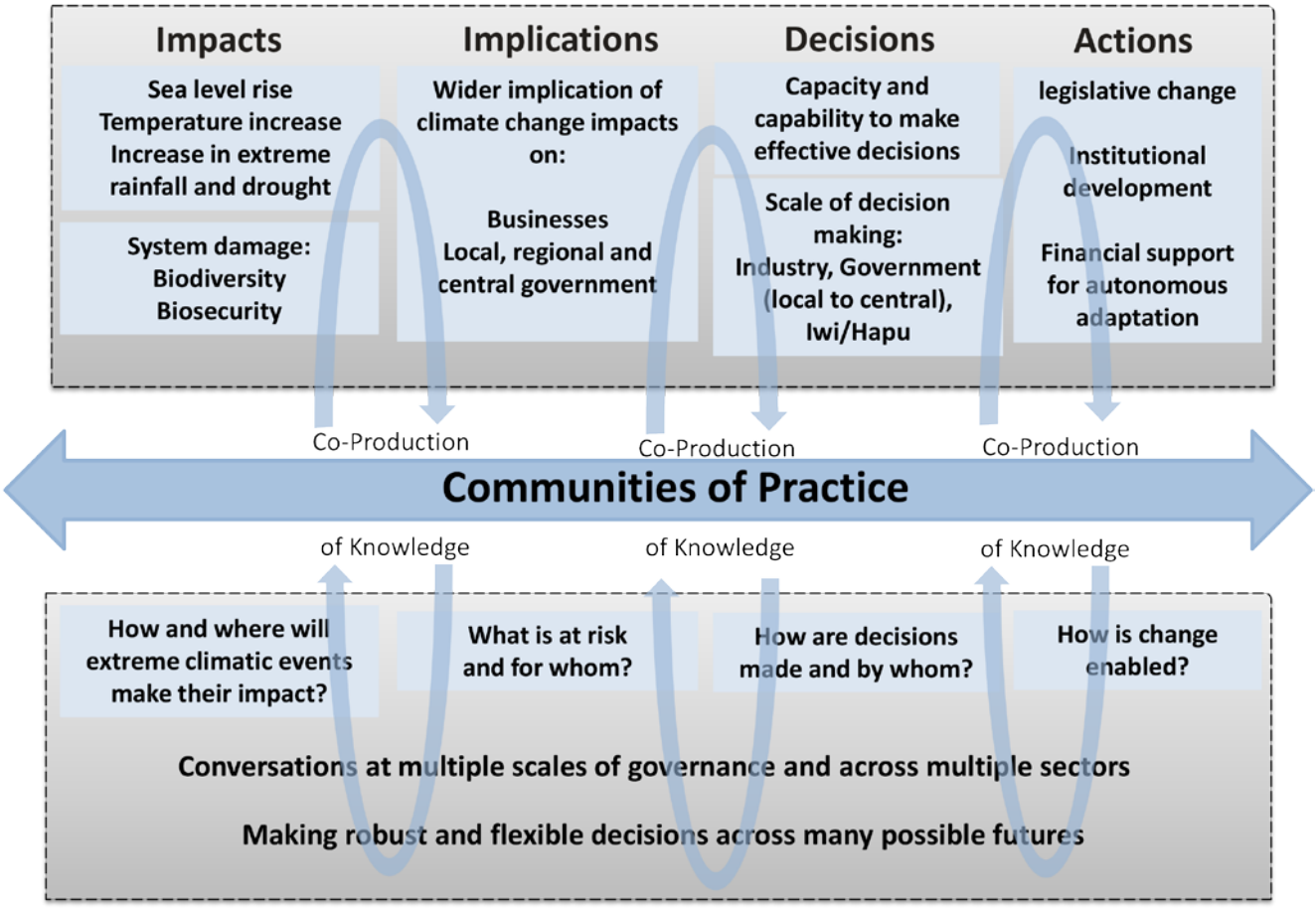


Figure 9: How an impact is defined and linked with implications and decision making.

Impacts of higher mean temperatures and increased drought risk

There were clear differences between public, private and influencer groups in the perceived impacts of higher mean temperatures and increased risk of drought (Figure 10).

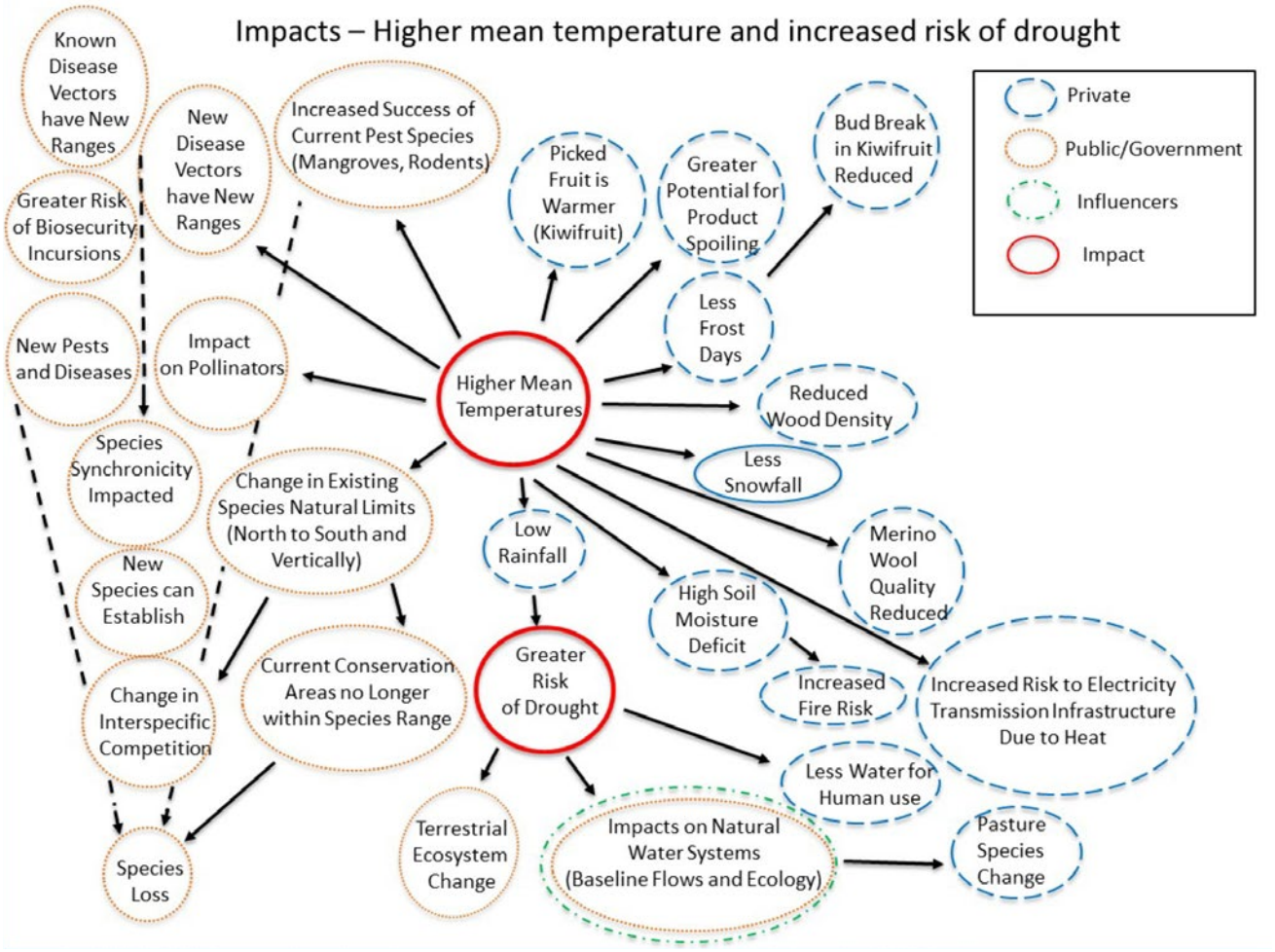


Figure 10: Perceived impacts of higher mean temperature and increased drought risk.

Private sector stakeholders were most concerned about the potential impacts of higher mean temperatures and increased frequency of drought on production, product quality, and productive capacity. For example, merino wool producers are concerned that milder and more variable temperatures in the South Island high country would reduce the quality of the wool, thus, affecting their livelihoods.

The kiwifruit industry identified lower yields due to decreased bud break as a direct result of fewer frost days, as well as fears kiwifruit would be exposed to higher temperatures during picking which could lead to skin blemishes (sun damage) affecting market returns. Increased temperature ranges could affect the operating conditions of electricity transmission and distribution lines, which would have flow-on effects to all electricity users.

Public sector agencies were principally concerned with the possible effect of higher mean temperatures on biodiversity, biosecurity, and in-stream values. For example, a regional authority suggested that warmer mean temperatures could result in the preferred optimal range for various native plant and animal species shifting south and to higher elevations. These new optimal ranges could be outside currently designated conservation areas, for example, with implications for the management of native species. Warmer temperatures could also result in existing pest species ranges shifting southwards, and allow new pests and diseases to establish themselves in New Zealand, should they make landfall. In-stream values in watercourses could be further stressed from higher mean temperatures

You tend to get more variation [in wool quality] in a season where one comes out of a drought and then hits a spring, and gets a big flush of feed. So, the feed levels go up and that can impact on tensile strength, so how sound the fibre is.
[Merino industry respondent]

Influencer groups fall into two categories: those with an interest in impacts affecting livelihoods (e.g., farmer organisations) and those with an interest in impacts for natural ecosystems (e.g., community care groups). The former had a particular interest in the impact of

drought on water supply and water quality, while the later were focused on maintaining minimum flows and water-quality standards in highly-valued waterways and on changes in terrestrial ecosystems.

Impacts of increased rainfall intensity and storm events

Differences between the issues raised by the private and public sector are less evident for the potential impacts of increased rainfall and storm events (Figure 11). The impacts highlighted were similar, but for different reasons.

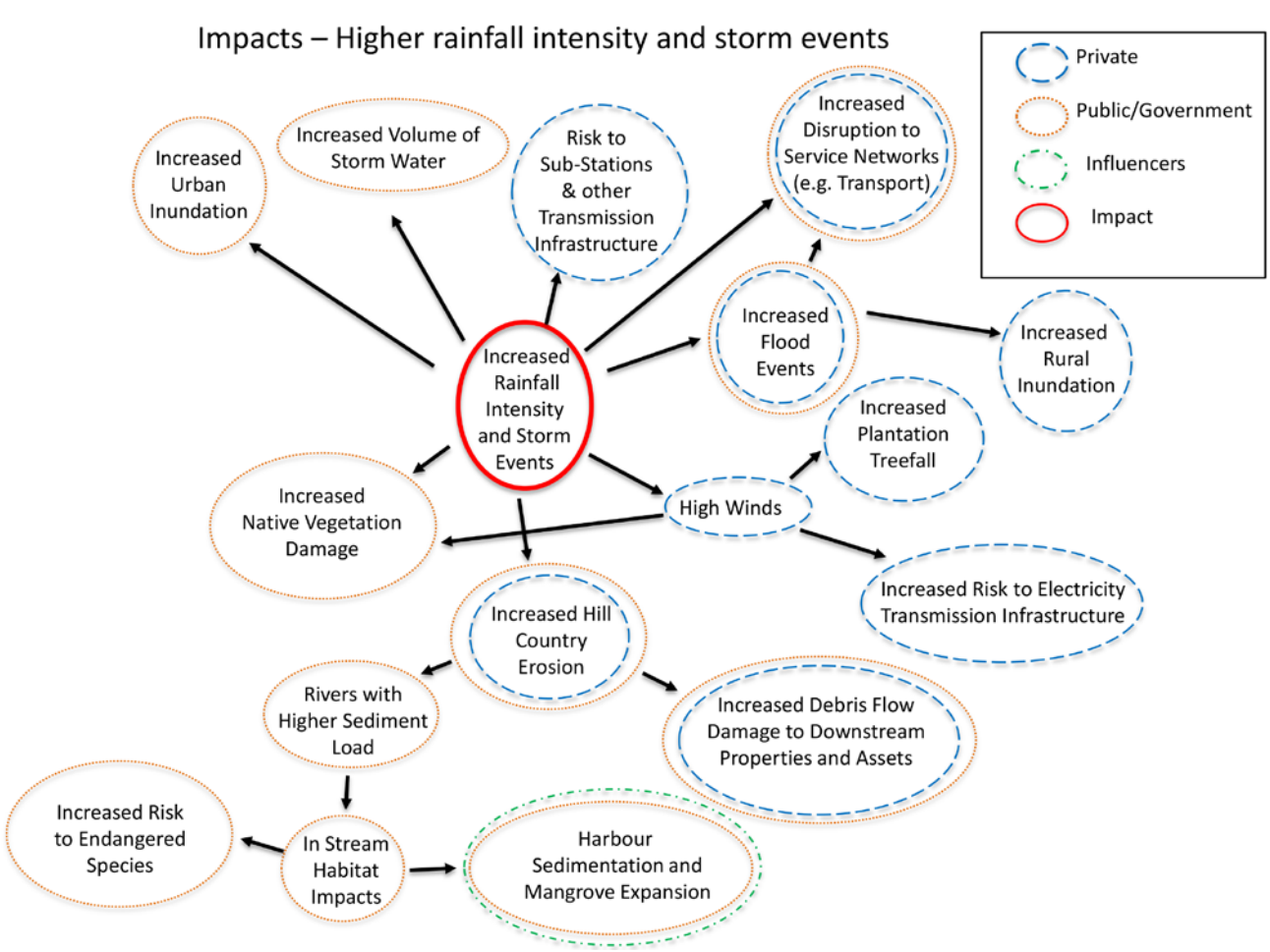


Figure 11: Perceived impacts of increased rainfall intensity and storm events.

For the private sector, impacts were most often described in terms of factors that would directly affect assets (e.g., irrigators) or their ability to produce and transport goods and services, or effects on quality. These effects include down time from wind events, or road closures due to erosion. For example, if landslides or floods prevent milk tankers regularly accessing farms to collect milk, the chilled storage units will reach capacity and product will have to be disposed of.

> *So, I would be thinking what we can expect in terms of those events and how might that affect our supply at different times of the year. So, how will it affect our peak [milk] supply and on the other hand how might it [affect us] if you've got those severe events happening in the middle of winter when we have a low level of supply, but we'd really like to retain a level of supply.*
> ***[Dairy company respondent]***

Other respondents described the impact of high winds on tree-fall in forestry blocks and the effects of high intensity rainfall on inundation on farms and orchards.

Influencer groups with a natural resource management remit were primarily concerned with specific impacts on locally-valued ecosystems, for example, sedimentation of coastal vegetation, rivers, and/or lakes.

Impacts of sea-level rise

Impacts of sea-level rise are similar between the private and public sectors, though the underlying rationale is very different (Figure 12).

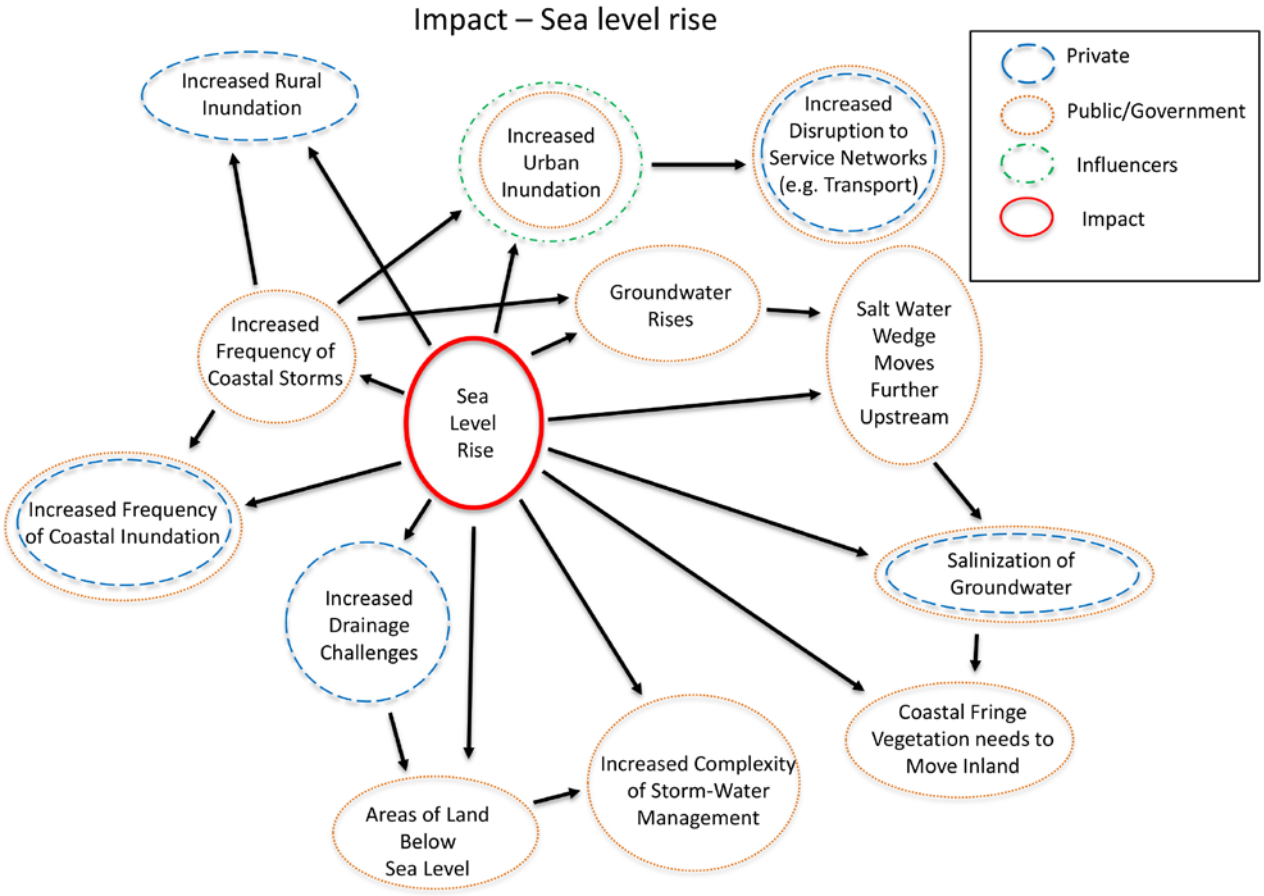


Figure 12: Perceived impacts of sea-level rise.

The private sector is primarily concerned with sea-level rise potentially affecting its ability to produce goods and services (coastal inundation or erosion of productive rural areas, drainage problems and salinization of groundwater) or its ability to move the product to intermediaries or markets (disruption of transport or service networks). For example, the dairy sector highlighted the possibility of a combined impact between rising groundwater tables and coastal inundation on low-lying dairy farms.

Public agencies, however, described the same impacts in terms of their potential to affect infrastructure maintenance and operations. Sea-level rise would affect storm-water systems, public water supply and service networks (roads). Long-term impacts on cities and the sustainability of pumping and/or coastal protection were also raised by local government. Sea-level rise would also affect coastal erosion (within urban areas) and have negative implications on coastal and estuarine vegetation biodiversity, and would complicate management.

Influencer groups highlighted the increased incidence of coastal inundation and the impact this could have on coastal ecosystems.

Differences between the public sector, the private sector, and influencers

In closing, it is notable that public sector agencies – local government in particular – were able to clearly articulate potential impacts on their responsibilities and in some cases, were in the preliminary stages of developing approaches to address them.

Conversely, the private sector has done little to consider how changing climate-risk profiles will impact its businesses. With a few notable exceptions – kiwifruit, electricity transmission, and hydro-generation industries, and, to a more limited extent, the forestry, transport, and merino industries – this research was the first time that many in the private sector have considered questioning the impacts of climate change on their operations. Private sector agencies have, however, engaged in discussions around the impact of the emissions trading scheme policy and some thought that was what we were going to discuss with them. As a result, serious questions regarding the capacity of private interests to manage changing risk profiles over time remain largely unanswered, since they are yet to consider them.

Differences between public sector, private sector, and influencer groups were largely a function of scale. A majority of national-level influencers were able to engage in detailed conversations on potential climate change impacts, although many had not yet advanced strategies to address them. Local groups, unsurprisingly, focused at a lower level on small-scale problem-solving activities, although were open to opportunities to address climate change impacts at higher scales as well. For example, with the coastal squeeze on nationally important coastal bird nesting and wading areas affected by sea-level rise, they saw a role in educating the community about sea-level rise and creating vegetated buffers next to residential areas at the coast.

Cascades

Cascades of impacts

A number of the impacts highlighted by respondents contain strong interlinkages between them. These have the potential to cascade, whereby one impact leads to a chain of events affecting a system, or affecting a number of domains. Examples of cascading impacts are provided below (See Box 5).

Sea-level rise is the driver of a range of cascading impacts that manifest in tensions around effective land use in coastal regions in New Zealand. Communities are beginning to notice salinization of coastal agricultural land as sea water enters coastal aquifers and kills off crops and grasses. To counteract this, land owners and councils pump the saline water off the land. This is an additional cost and expensive to maintain. It can also result in coastal land (especially peat-based land) sinking. This process raises the spectre of deciding between land uses, as the current use becomes less economically viable and wetland creation becomes a more practical option. This in turn can cause tensions in local communities as land owners typically want to maintain the land under farming use. Meanwhile, councils and others within the community see a better long-term solution in managed coastal realignment by letting the land flood to create wetlands that can be a natural buffer as the sea rises, for example, or retiring farms from their current use and converting them to alternative uses, such as flax farming or tourism initiatives such as bird watching sites with bird hides and walkways. These were present and real-life options under current consideration.

A regional council respondent illustrated the challenges with the complex management issues arising from sea-level rise and land subsidence:

> *We've got areas that are sinking and we believe by the end of the century they may have dropped a metre ... we can't continue to keep on building up the levels of the stop banks. Ratepayers have got a finite rating base and can't continue to be paying to support that high level of service. So, we've been looking at how else could we manage these schemes: What are our options?*
> ***[Regional councillor respondent]***

Box 5. Cascade of impacts: Sea-level rise and land use change

Over the last century, New Zealand's low-lying coastal wetlands have been drained to make way for farming and subsequently 'protected' from flooding by stop banks, and from tidal flows by sluice gates. However, there will be affordability limits for protection as sea levels rise, since a small base of farmer rate-payers will be unable to sustain the cost. There will be growing pressure to put the land back into wetland as a coastal buffer.

As one regional councillor said:

We've traditionally provided a 100-year protection level for flooding. But what we're seeing is that scale of event happening every 20 years. And not so long ago we had three within two years. And we can't continue to keep on building up the levels of the stop bank. Ratepayers have got a finite rating base and we can't continue to be paying to support that high level of service. So, we've been looking at how else could we manage these schemes: What are our options should climate change happen? We have done economic analyses on the value of the land that the scheme is protecting and thinking, this land; actually it's not worth paying $2m to have a high stop bank in this area. Maybe we should let this area flood and then compensate the landowner when it happens as opposed to continually doing these hard engineering sorts of solutions.

Interlinking drivers in the Marlborough Sounds provides another example of a cascade of impacts. There, a combination of changes in water temperature, its chemical composition, and sedimentation is leading to loss of kelp (seaweed). As ocean waters warm in response to climate change, particular *Macrocystis* species (kelp) cannot survive the higher temperatures and are dying back. Heavier and more frequent rainfall events (linked to climate change) and agricultural practices in adjacent hill country have resulted in increased nutrient run-off, topsoil loss, and erosion exacerbating the problem. Research has linked the loss of kelp with a decline in the population levels of kina, rock lobster, and paua in the area (NIWA, 2016).

Respondents noted that there are secondary risks from the change in frequency of storm events, or the co-incident alignment of climate extremes. Fire risk, for example, increases when there are prolonged higher temperatures, lower rainfall, and increased drying winds. This affects pastoral farming, forestry, and indigenous forestry land.

Some cascades of impacts of climate change and their implications are not yet known. An example reported elsewhere in the CCII programme describes factors affecting beech masting. Modelling suggests an increase in the number of 'mega-masts' with flow-on effects for growth in population of pest species and negative implications for native bird populations. This in turn has consequences for public agencies' budgets trying to "hold on to species". Other impacts include unknowns, which were perceived as challenging adaptive capacity.

Respondents also identified climate change impacts cascading into implications in the tourism sector in the Queenstown and Wanaka regions. Discussions between those responsible for managing the Crown estate and local tourism operators and community members, highlighted a number of climate change impacts in the region, including reduced snowfall projections. This discussion led the local ski field operators to commission a study (Hendrikx, Zammit, Hreinsson, & Becken, 2013) about the impacts and how they could change the way they managed their operations. This in turn led to adaptive planning practices by the ski-field operators, within clearly identified operating conditions, to manage the changing climate risks.

When we went and talked to the industry [in Queenstown], we didn't even talk about climate change. We just talked about the weather and the influence that the weather had on them and said by the way, what would happen if these sorts of conditions changed a whole lot and we drew up a couple of graphs and stuff like that, had a workshop around it – and what we found most fascinating at the end of the day was several things: the industry became really engaged, and was actually quite interested.
[Conservation manager]

Climatic conditions in New Zealand can have complex implications for kiwifruit growers because they compete in international markets. For example, a particularly dry season produces smaller kiwifruit. However, if the winter is mild, there are lower fruit numbers, but fruit size is large. There is an optimal fruit size for a variety of international markets, so larger fruit size can impact locally, due to a very high price per piece of fruit for local consumers. Kiwifruit cultivation is also linked to landscape-scale interconnectivities; for example, the link between waterways, catchments, and access to the port for export. Disruption from transport network stoppages due to landslips and catchment-level sedimentation into waterways and then to the harbour can hamper access to the port, and thus increase production costs.

The linkages between maintaining and protecting biodiversity, species and habitat conservation, and managing for climate change come together in the management of wilding conifers, such as in the Queenstown Lakes District and surrounding areas (and other areas of New Zealand high country). Exotic plantation conifer species grow vigorously in this area. Their seedlings invade and out-compete adjacent areas of low open indigenous tussock grasslands. Wilding conifers are a significant threat to local habitats as they remove sizable volumes of water from catchments and prevent the growth of native flora. Climate change is projected to reduce water availability in this region and wilding conifers will exacerbate this effect. Related impacts identified by the forestry sector respondents are illustrated here:

Probably the big two issues, I guess, from climate change, will be increases in fire and increases in potential biosecurity [threats], in the terms of shift of pests and diseases and also new ones coming in and being able to get a hold.
[Forestry sector respondent]

The land, water, and climate change nexus

Climate change impacts and implications are interconnected. While the results of our research revealed stakeholder concerns with direct impacts on climate and biological systems, for example, there are also flow-on effects for social and economic communities. These impacts, however, arise not only from downstream cascades of impacts with implications, but connect to one another in increasingly complex ways.

An integrated "nexus" approach emphasizes functional linkages between issues usually treated separately, e.g., food, energy, and water. This approach has emerged from systems analysis based on a robust body of scientific evidence. Its application to decision making, policy analysis and planning is growing.

Findings from RA4 show nexus issues arising from the interactions between land, water, and climate change. With climate change impacts and implications creating challenges, the nexus between these three issues is critical for decision making about climate change adaptation.

One way to address interactions between water, climate and land use is to map the connections and identify links between different sectors. Box 6 shows an example of how land-use change, climate change, and water interact.

Box 6. The changing land use, climate change, and water nexus

Throughout New Zealand, land use is changing from dry stock (pasture grazing beef cattle and sheep for meat and wool production) to dairy. Lowlands, which were traditionally used to fatten beef cattle and sheep before sale, have been converted to dairy farms throughout the country. The traditional method of grazing stock in the hills and then bringing them down onto the flats for fattening has changed. This is forcing farmers to relearn how to farm.

*Suddenly the whole enterprise is up in those hill countries, and so basically you're having to re-learn things. How do you have your whole industry up there when you can't have lowlands at all? So, you've got a changing land-use pattern and over top of that you've got environmental changes – especially around the management of nitrogen and phosphorus. And then on top of that is changing climate. [**Farming influencer respondent**]*

More intensive land use is being promoted as part of a national economic development strategy.

*In New Zealand, we're pushing and pushing further intensification of dairying and you can see what's happening to the environment as a result. And I'm not saying stop intensifying, but I'm saying whatever we do we've got to try and maintain that sustainability balance, so we're not any worse off. But then there [are] all these conflicts, they say manage your water, clean your water up. But on the other hand, they're saying economic development is king. It's not been an easy place to be. [**Regional councillor respondent**]*

*Land and water issues, however, tend to be viewed in isolation. Land and environment plans, for example, focus on "identifying your at-risk country. So, the stuff where you're going to get your most runoff, the stuff that's vulnerable to grazing. It really encourages you to identify your waterways and mitigate risk to waterways, and things like that." [**Farming influencer respondent**]*

While managing hill-country erosion is vital, respondents also indicated the need to consider it in a more cohesive fashion. Intensification and the expansion of dairy, for example, are pushing grazing stock onto steeper hill country land. With increased rainfall events, erosion may become more problematic with heavier stock on steep terrain.

The erosion of hill-country land is also then connected to downstream issues such as mangroves. As discussed with workshop interviewees in the Bay of Plenty, mangroves are increasingly prevalent in Ohiwa Harbour. Warmer winter temperatures and fewer frosts – which "knocked" them back – have enlarged their range, threatening highly-valued ecosystems around the harbour. Increased storminess can spread seedlings across beaches where they might have been previously absent.

Management and decision making in the nexus

Current governance, institutional arrangements, and decision-making processes often take a "siloed" approach to dealing with natural resources. This can lead to unsustainable policy and development choices. For example, throughout the South Island energy-intensive inter-basin water transfers and ground-water pumping are being used as solutions to water scarcity, in order to boost productivity from the land-based sector.

To address the issues arising from interacting, complex climate impacts, new ways of communicating and framing the discussion may be required and more cohesive and linked-up ways of exploring impacts and implications are needed. "There are lots of tradeoffs, and I think that climate change is something that's coming at us, and we're having to change the way we think about some things as a result." [Regional councillor respondent]. This could involve reframing the issues in terms of natural capital or ecosystem services in order to engage more effectively with government.

*What [we're] really trying to do is put it into a language, which doesn't necessarily talk climate change up front, but says we're not going to have the same levels of natural capital or ecosystem systems delivered from this geographic entity that we would under Scenario XYZ versus ABC. Oh, gee, the three degrees difference in temperature – so, it becomes a more integrated chat because climate change is bubbling under the service and we're not so explicit about it. [**Conservation estate manager respondent**]*

Local solutions, "governance at a grower level", were also suggested by a horticulture industry respondent along with identifying and building awareness of the interconnected nature of multiple issues.

> *How do we build in recognition of long-term, sort of, multiple issues like climate change into those management priorities? If that gets done, then the mechanism is there to implement it, but it's again back to communicating [the]urgency of it or the importance of it, and then structurally how that filters back into the work programmes.*
> ***[Conservation estate manager respondent]***

Planners and councils when addressing cascading and nexus impacts on land and water resources require integrated and cohesive management systems: "I don't think you can address some of these weather risks or climate risks in isolation, you've got to take a holistic approach." [Forest industry respondent]. Managing for soil erosion and water quality, for example, needs to be considered alongside the potential for increased extreme precipitation events and the effects of increased use of N-based fertilisers arising from intensification practices.

Climate change will increase pressure on resources, and thus add to the vulnerability of people and ecosystems, particularly in water-scarce and increasingly-marginal regions. A nexus approach is needed to enable climate mitigation measures to be more 'water smart', for irrigation to be less energy intensive, and to avoid damaging consequences for food production and other vital ecosystem services.

The interaction between water, climate, and farm-level responses is across climate-affected regions. Climate change is likely to exacerbate existing drought risks, particularly for eastern areas, such as Bay of Plenty and Hawke's Bay, and there is already evidence of the felt impacts of climate change on drought risk (Harrington et al., 2014). For many farmers, using irrigation might be considered a reasonable adaptation strategy. However, if a majority of farmers plan to irrigate, demand may greatly exceed the available resource, forcing changes in land use to less water-demanding activities and shifts in activities to other regions. Again, social and economic consequences flow from such changes.

In order to avoid this type of compounding effect at the nexus, greater attention is needed to the potential policy implications of current – and future – decision-making, and its implications for climate change adaptation. A nexus approach demonstrates systemic thinking, where there are complex linkages and feedbacks between domains of interest, and the development of integrated solutions to guide decision making. But successfully applying nexus thinking to specific locations and challenges is by no means an easy task.

DECISION-MAKING IMPLICATIONS

The impacts identified in this report have broader implications for stakeholders, as shown by the cascades of impacts discussed. Furthermore, these have implications for governance and institutions, decision making, information about climate risks, and capacity and capability to address climate impacts and their implications.

Governance and institutions

Governance refers to the process of regulation, coordination, and control that enables or constrains the actions of members of a society (Alexander, 2005). The concept can be applied in different forms through a range of institutions of practice, independent market transactions, mixed forms of control oversight, or integrated organisational forms like public bodies and corporate firms for recurring transactions with high interdependence and uncertainty. These are discussed below as they relate to climate change impacts and their implications

Governance influences how public agencies discharge their various responsibilities; private decision-makers sit within their own governance arrangements that influence how they interact with public agencies on climate change-related issues and, in turn, their decisions affect the ability of public agencies to achieve their functional objectives. There are also a range of public and private influencers of public policy decisions that have different governance arrangements affecting their interactions with both public and private agencies. All of these governance forms and interactions are discussed here as they affect and are affected by climate change impacts and adaptation.

Public sector

Two issues were repeatedly raised by respondents: fragmentation of governance across scales and within organisations; and the need for greater linkages across public agencies where decisions at one scale/function affect another.

Examples include local government managing hazards at two levels, which has implications for liability for decisions as these hazards are exacerbated and change with changing climate (at the coast and on flood plains in particular). The governance of infrastructure and utilities for urban land-uses is split across levels of government and in special-purpose arm's-length agencies for transport, power supply, and the three waters (storm water, water supply, and waste water). These latter services are also split between public agencies for their delivery. This was reported as creating integration issues, when considering the effects of climate change on any one of them, where there are effects on another. While some of these services are delivered via Long-Term Plans under the Local Government Act, not all are, e.g., where national highways and local roads and bridges affect each other, and where national power transmission affects local delivery of electricity services.

Also, within public agencies functional areas are often managed separately. Across agencies there are different levels of power over resourcing and policy decision-making that influences whether and how climate change implications are considered.

The need for greater national consistency in addressing climate change impacts across New Zealand was consistently reported by respondents. "While councils can talk with each other, central government needs to provide guidance around consistency of approaches." [Regional council staff respondent]. National policy statements (NPS) were seen as key and the role played by the New Zealand Coastal Policy Statement (NZCPS) was welcomed. However, not having an NPS that covered flood-risk management was seen as a barrier to effective integrated consideration of climate change effects on flood risk: "A major constraint for river management is not having an NPS for flooding." [Regional council flood manager]. The power of central government guidance strengthens local government governance when making hard decisions that are in the public interest as reflected by an elected councillor:

> *So, yeah, that's where I think I would welcome a much stronger cohesive position for the whole country on climate change. Which then gives us a bit of strength to our backbone. Because, you know, we're actually struggling a bit with our RPS [Regional Policy Statement] provisions around natural hazards, where we are saying: You know what? We think this is really important for the future and we want this.*
> ***[Regional councillor respondent]***

These factors, in combination with the short-term focus of decision makers, were described as creating barriers to integrating the effects of climate change into decision making, and barriers to how policy decisions might be adjusted in future, as the climate changes.

The coordinating and communicating role of regional councils, improving understanding in central government about the implications of climate change across economic and social sectors, and the need for national leadership in support of local government responsibilities for considering climate change effects, were seen as key to better integration of climate change consideration within decision making at all scales.

The institutions and the organisations implementing decisions were also closely related to the governance theme. While a risk-based approach was being implemented through the Resource Management Act (RMA) – the only statute to explicitly mandate those operating under it to consider the effects of climate change – some of the instruments being used are having the effect of locking in current development patterns at the coast and on flood plains in particular. Spatially static hazard zones and stopbanks were the most frequently cited measures in this context. There have been some new approaches developing, such as using risk-based set-back lines, raised floor levels, land-use activity constraints, and relocatable houses. These, however, are being implemented under the RMA, where practitioners strive for certainty of outcome for those affected. There were two issues reported with these approaches: there is a time inconsistency in decision making by those elected to office for short periods of time; and the use of static measures does not adequately account for changing risk profiles. While review periods are a part of the planning system, in practice the measures persist, because uses are embedded as existing uses and are hard to change.

Where attempts have been made to reduce climate risk, these were being challenged in some areas and new approaches were being called for by local government. It was clear that an effect of the Canterbury earthquakes (which coincided with this research) has been to initiate a rethink of institutions and measures for managing long-term risk, e.g., insurance settings and Reserve Bank rules for reinsurance.

The Reserve Bank has basically set in rules that from 2016-2017 they have to buy reinsurance level to 1 in 1000-year return events.
[Insurance industry respondent]

It was suggested that the climate change effects provision in the RMA be applied across other related statutes like the Local Government Act, the Soil Conservation and Rivers Control Act, the Building Act and the Building Code, the Civil Defence Emergency Management Act, the Earthquake and War Damages Act, and as part of the Reserve Bank rules applying to banks for lending. Consideration of the role of the Long-Term Plans, strategic reviews, coastal plans, and regional policies was also raised by respondents for examination of how climate change impacts and their implications can be considered over longer time frames.

However, respondents were clear that, without the ability to fund climate change adaptation where people and assets are at risk, it was considered unlikely that measures currently in use would be effective in reducing exposure and vulnerability to climate change. In this regard, the extension of the EQC system for anticipating risk was suggested. Population and land-use changes were highlighted influencing the ability of long-term plans to be adequately funded through current rating levers.

As one industry respondent commented, "Today's policies influence adaptability in the future." [a water engineer]. However, respondents observed other pressures on government to change sections of the RMA that reduce the public good safeguards that drive the sustainability of outcomes for future generations, thus, increasing the potential for risk transfer between public and private interests, and between generations. The One Plan in Manawatu, coastal management planning in the Kapiti District, the Ruataniwha dam in Hawke's Bay, and national water standards were cited by respondents as cases where such pressures were brought to bear.

Private sector

There were examples of governance integration across the business of a firm for the expressed purpose of managing global risk; for example, the merino industry is vertically integrated from grower to market. This enables long-term risk-spreading. In the forest industry, managing and responding to pest risks is a

shared responsibility between both private and public interests.

However, there were other examples where governance arrangements create barriers to managing climate change risks. Carbon markets, for example, are an important market mechanism for managing forest enterprise risk over time. Current policy settings, however, (which are under review) 'lock in' risk exposure for the industry, by excluding them from trading. The inability to tap into this opportunity was of particular concern to iwi forestry interests.

The effects of uncertainty on decision making are also evident. In some sectors, stakeholders are planning for current conditions, assuming only limited variability, or prioritise the effects of 'known' risks such as market prices over the unknown effects of climate change. Known near-term impacts were also prioritised over long-term ones. Other respondents described the ability to pay for adaptation as being a motivator for new approaches to be developed, port authorities, for example, were concerned with land becoming inundated by sea-level rise.

Influencers

Different governance arrangements can be used to highlight beneficial design features that could be used to address climate change impacts and its implications. For example, Fish & Game New Zealand is a public entity, funded by its membership and audited by the Office of the Auditor-General. This innovation gives it high levels of both public and private accountability and independence. However, where there are collective procedures that cut across such independence – as in the Land and Water Forum – tensions can arise. The Land and Water Forum is an example of a public/private/influencer institution that has been able to work through a complex issue and arrive at agreed recommendations for a way forward. However, it has no implementation function or power, nor any public accountability. Its recommendations, therefore, are largely dependent on the government of the day to implement.

Decision making

We sought to understand what drives decision making across public, private, and influencer groups. This was the point of departure for understanding how climate change might affect decision making now and in the future, and what information needs/frames/time frames the different groups might require. Findings are discussed according to the types of decisions; decision drivers; framing of climate change including the timing of decisions, whether the future was considered, and legacy issues; the role of uncertainty; and how decision making is already changing.

Types of decisions

A wide range of public-decision types were identified, including operating design conditions for utilities, power line, generation, transmission, underground services for the three waters, flood risk management, coastal zone management, land-use planning for urban development, and transport networks. All of these decisions were expected to be impacted by increased heavy rainfall; wind and coastal storms; sea-level rise; enhanced landslips; and disruption to movement of goods and people, and their servicing by utilities and water services. Decisions about water resources included tolerable limits for in-stream uses and how to better account for thresholds before they are reached, using design triggers, and management pathways, for example. Flood protection and coastal management and planning decisions were around whether and how to use hard structural or soft protection measures, and where their limits might be, as well as what the community tolerability to risk was. How to manage change over long time frames was an ever-present challenge mentioned by regional councils especially.

Private sector decisions are affected by transport network impacts, effects of drought on production timing (kiwifruit) and productivity (feed movements), and access to markets. The strong dependencies between public and private sector decisions were a notable feature of the research findings. The tourism industry was characterised by short-term decision-making that had flexibility to manage risk by shifting between markets and locations in New Zealand. Little thought had been given to how climate change might stress that flexibility in the future. The ski industry was the standout, having identified climate-related triggers for management regime change. The merino wool industry was also unique in that they had a strong strategic decision-making culture based on branding fine wool that was entirely dependent on a particular climate regime. Many of the other private-sector players had not developed strategies for how climate change might affect their current business operations. Some, like the kiwifruit industry, were aware that they were already adapting to climate changes in ways that potentially had negative flow-on effects for energy consumption (see Box 8).

Decision drivers

Exploration of decision drivers revealed two major drivers affecting public and private sector groups differently. Public sector groups are largely driven by regulatory frameworks and functional mandates, whilst the private sector and public sector service delivery agencies are driven largely by economic incentives, including land prices. Episodic extreme climate events motivate both groups, but differently. There appeared to be less inertia in the private sector to such events, where they adapted quickly, although, in most cases, incrementally; for example, adaptations might include changing markets, changing production settings, and changing feed sources (some institutions are already responding, such as breeding different plant materials to create diversity to contribute to, for example, forestry sector resilience to new diseases as a result of temperature increases).

On the other hand, inertia in the public sector was far greater than the private sector. Institutional frameworks (current procedures and accountabilities) dominate the thinking and decision-making style of the different disciplinary groups within the different decision settings – regulatory processes, for example. Risk aversion is rife and single-purpose policy decision-making is driven by disaster or climate events in local and central government. Integration of institutional mechanisms is weak, meaning actions in one policy domain can cancel out initiatives in another. For example, engineering resilience of infrastructure may lock-in current design parameters and be inflexible as climate changes.

Interestingly, changes in insurance policy settings showed greater consideration of hazard risks following the Canterbury earthquakes in 2010/11. This was manifest in proposals to elevate hazard management in the RMA and to develop a more comprehensive NPS for all natural hazards. Changes to central bank oversight policies with respect to risk management as a result of the impact on New Zealand's economy of the Canterbury earthquakes, has potential to leverage greater consideration of climate change risk if the scale of climate change impacts is acknowledged.

Influencer groups are driven by public or private interests, and, in coastal areas, often by both. Influencers comprise a range of consumers of local and national services, ratepayers concerned with how rates are spent, decision processes considering hazard risks and climate change adaptation, development interests, and those concerned for common pool resources (e.g., habitats, water, amenity, and recreational interests).

Framing

Public and private groups have different framings of climate change, often derived from their dominant institutional and disciplinary practices. The clearest distinction between the two groups was the longer-term focus of public agencies more generally, compared with private sector businesses. Central and local government statutory mandates include precaution, interests of future generation, cumulative impacts, and uncertainty management, of at least 100 years for long-lived activities and 30 years for infrastructure, nudging public decision-makers in a long-term direction.

However, the practice is mixed at best and short-term at worst. Even though this longer time frame is mandated, the practice is to plan to shorter five- to ten-year periods as part of the Long-Term Plans under the Local Government Act. There was little evidence of investment decisions within shorter time periods being linked to their ability to cope with climate changes over longer time frames with the exception of electricity transmission (see Box 7).

Some strategy plans are being developed for climate change adaptation, in municipal councils several hazards (tsunami, storm surge, and sea-level rise) are being linked together, but the focus to date has been on emissions reduction, rather than adaptation. There was a tension between achieving regulatory certainty and managing a changing risk within the regulatory environment in which decisions were being made. Liability was seen as liability for getting the information wrong, rather than liability for not implementing statutory responsibilities, and this was exacerbated by the tensions between the statutory requirements and pressures on decisions makers in a short-term electoral cycle to satisfy short-term private interests. The following perspectives of elected councillors were repeated by regional and district council staff at workshops:

There are no consequences if we don't address climate change as it is difficult to enforce compliance with the RMA. There is liability for non-disclosure of hazard information, but litigation risk of publicising hazard information is stronger on council behaviour.

Councillors are subject to the will of the community, so if there was a national-level policy it backs up council if communities are not wanting action, because of individual property issues.

The average person is more concerned with day-to-day activities in the short term ... because dealing with unknown and future requirements [is not easy to visualise] and because annual things are easy to visualise. Each elected members has to make a call.

The conjunction between changing risk profiles with climate change and the transfer of costs from private investment decisions to the public and to future generations, was seen as a framing challenge for decision makers. Alternate framings such as natural capital or ecosystem services were beginning to be used in some public agencies, and could help shift decision-making practices to consider longer time frames. Resilience was another framing that had been taken on in the infrastructure policy arena, gaining attention following the Canterbury earthquakes. However, resilience is most often interpreted as "bouncing back", a strictly engineering sense of the concept, rather than a recognition that risks are changing such that bouncing back to the status quo systems of delivery may not be flexible enough for the rates and magnitudes of change likely with climate change.

There was evidence of incremental adaptation occurring with respect to sea-level rise and flood risk. For example, the NZCPS was effective in motivating a precautionary approach using progressive graduated risk-based planning controls, provision for relocatable housing at the coast, raised floor levels, and flood proofing measures in flood plains. However, there are physical and affordability limits to existing instruments. Addressing the impacts of sea-level rise and the financial implications of the legacy decisions that located people in areas at risk from sea-level rise and storm surge, will require new approaches that are only starting to emerge in New Zealand (Lawrence & Haasnoot, under review; LGNZ, 2016).

The time frame of most private sector respondents was short, only two to five years. However, in some sectors this was balanced by greater ability to change course, at least in the medium term. Farmers commented that a 30- to 50-year time frame was "academic", and that irrigation would be an effective adaptation to climate change. However, some local government respondents pointed out that areas augmented by irrigation were the same ones where water shortages were likely to increase due to climate change. Infrastructure investments, in that case, could be maladapted to a changing climate, leading to greater exposure in the farming sector to climate risks with consequent and cascading financial and social impacts. There was also nervousness expressed by farming influencers about the investment costs of irrigation; for example, "I think the challenge is that farmers see the cost that they'll have to invest [and this] makes them nervous."

The tourist industry had prepared a 2025 plan but risk decisions were being made on short time frames. The forestry sector typically has a 28- to 30-year investment cycle and this appeared to incentivise risk management practices, e.g. a company is using of Douglas fir in high-risk wind and snow areas, and where research is ongoing into breeding for resistance to disease. These are examples of complementary risk management practices that primarily are addressing current risks, but also address risk that is expected to increase with climate change

Uncertainty

Uncertainty emerged as a specific framing that created a barrier to considering changing climate risks (see also Section 5: Barriers to decision making). Some councils are still operating on a static framing of climate change risk, driven largely by the regulatory frameworks they operate within and fear of a court contest. Closely allied to this was an aversion to using the precautionary principle by some councils, because stakeholders see it as contrary to evidence-based policy development. This was particularly so for flood and sea-level rise risk levels. As one local government respondent said, "Some stakeholders see science as getting in the way of their development interests." Nevertheless, some councils had started to use scenarios and to communicate the significance of uncertainty for current decisions that may be affected by climate change. Local government workshops and interviews showed emergent thinking about how to manage this uncertainty for particular localities and catchments. For example, some councils were starting to consider what triggers could be used to change practice for particular functions (sea-level rise, flooding, storm water, biodiversity and biosecurity). There was consensus on climate change happening, despite uncertainty regarding magnitude and frequency of damage. Some councils saw this as 'too hot to handle', while others were using their sustainability plans, regional coastal plans, national park plans,

settlement patterns reviews, and other strategic planning processes to explore ways of dealing with the uncertainty in the present to avoid greater problems for them in the future. As one regional councillor said:

> *There's a lot of thinking about what might happen in the future and it's starting to be reflected in the planning documents. I think where we should be going is taking a leadership role and having a conversation with the public about how we believe there is now some certainty around the fact that our climate is changing and that we will have an increase in sea level, that we will have a lot more extreme weather events [and] this is going to have implications for the way we manage our storm water [and] where we put houses. [**Regional councillor respondent**]*

The Reserve Bank's risk directives to banks require them from 2016/17 to buy reinsurance to underwrite 1:1000-year events to help manage uncertain natural hazard risk. The private sector also has a number of ways of managing risk already in operation. The risk future climate change poses to power generation, for example, is managed by specifying operating ranges that reflect the uncertainty in projections. The ski industry has also identified operating ranges for snow making based on an assessment of future climate changes. For the dairy sector, risk management was more pragmatic. As one dairy sector representative commented, "Dairy still works off likelihood and will want to see more risks emerge before acting." Other farmers regarded uncertainty as the "unlikelihood that it will happen, so it raises the need for monitoring". This 'wait-and-see' view was echoed by a forestry industry representative who said that, "We see climate change as grasping at straws, while other conditions have a greater impact on our business."

Changing decision making

The impacts of climate change were described by a majority of stakeholders as having direct effects on operational activities. In addition to increased information and understanding about global changes, more broadly, the analysis also revealed changes in thinking and practice relating to management of these effects in both public and private sectors.

Most activity in the public sector has occurred at the level of local government, by regional and district councils. In some regions, councils have begun to share information, planning approaches, and experience in implementation and have commissioned studies of sea-level rise and potential effects on coastal development. There are already examples of successful implementation of regulatory regimes to manage risk with limited contest (e.g., the Hawke's Bay Regional Coastal Environment Plan and the Tasman Resource Management Plan Change at Mapua), compared to the Kapiti Coast District where processes foundered. Other examples were identified in the research including processes involving public interests in the communication of climate change risk using third parties and community groups as boundary agents (e.g., the Bay of Plenty Regional Council and the Western Bay of Plenty District Council). The Environment Court is increasingly using its veto to decline subdivisions in coastal areas deemed at risk from erosion and over the life of the proposals (Carter Holt Harvey[10] and Gallagher[11] decisions in Tasman District) or require developers to make a bond payment to council for future removal of buildings once sea levels reach a prescribed level (Mahanga E Tu case at Mahia Peninsula[12]).

In the case of the Hauraki Plains, drought management triggered closer consideration of water availability and the possibility of changes in future land use. Some councils (e.g., Western Bay of Plenty) have communicated limits for servicing coastal settlements and identified "no go" areas, or signalled potential un-insurability of coastal properties. Framing climate change within a broader context of sustainable flood risk management, the Bay of Plenty Regional Council discuss the coping range(s) for a range of present and future activities, and discuss how these can be managed.

Electricity transmission and generation sectors also have risk-based levers that enable them to manage their inputs and outputs in an adaptive and flexible manner (Box 7).

[10]Carter Holt Harvey HBU Ltd v Tasman District Council W025/2013
[11]D and C Gallagher v Tasman District Council W245/2014
[12]Mahanga E Tu Inc v Hawke's Bay Regional Council and Wairoa District Council W083/2014

Box 7. Managing transmission system uncertainty through redundancy, criticality, and diversity

Legal obligations set design limits in New Zealand at 1:2500 (as the annual probability of exceedance) for earthquakes and 1:500 for wind. These levels are then compared to the function of an asset, because not all are as essential as others. Technical and economic criteria are then applied.

For example, transmission lines are designed to a lower standard than substations. Transmission lines are very robust and simple, and fast and cheap to reinstate (between 24 and 72 hours). Multiple lines run between substations, providing functional diversity. Conversely, substations are geographically concentrated, have more items of plant that perform a single function, are very expensive, and have long replacement times. For example, delivery of a power transformer will take over a year from date of order and they weigh several hundred tonnes; a significant logistical exercise to replace. Even a spare takes two to four weeks to get on site, so substations have more stringent design standards (1: 2500 years) than transmission lines.

Not all lines or assets are created economically equal either. The core grid – 220 kV – and anything greater than 150 MW are designed to deterministic standards (two of everything), so if one part is 'lost' the other parts can continue running with no interruption. For investment in anything less than 220 kV or 150 MW, the criteria are purely economic. Sensitivity analysis of $20K/MWh (megawatt hour), $5K/MWh and $35K/MWh can be used to highlight what is at risk in the event of non-delivery due to different load concentrations.

This same process could be used to consider climate change risk on the transmission system. For example, for heat, snow and ice, wind, sea-level rise, flood events, and related landslips. Redundancy, criticality of asset, and diversity of system design are the factors that enable Transpower to manage uncertainty and dynamic change in their system. However, distribution companies are more at-risk, because they have more limited funding to manage the logistics costs of such a protocol.

Operational departments also use contingency funding to manage climate shocks, though they recognise that this is essentially post hoc and elements could be anticipated better and included in management plans.

The private sector showed limited examples of changed practice motivated by climate changes. The kiwifruit industry example is an exception as shown in Box 8. They are actively changing practices in the orchard to manage the effects of climate on energy demand and disruptions to market access. Breeding of new stock that can withstand the changed practice is also underway.

The Canterbury earthquakes have changed the way the insurance industry is managing hazard risk. This is likely to have flow-on effects for how climate change risk is managed for floods, sea-level rise, and other coastal hazards. Insurers are now typically more risk aware and sensitivity to climate risk signals from the reinsurance industry. This will only increase as the climate changes.

Cross resistance breeding of forestry stock is an example of adaptation within an industry as a direct result of the need to be more resilient across a range of future climate scenarios. The forestry industry has also initiated a partnering with central government, for managing the entry of new pests.

Box 8. Cascades of impacts Kiwifruit industry

Climate change has the potential to create a cascade of effects, particularly post-harvest, in the kiwifruit industry, including impacting on cool storage, fruit quality, energy costs, and transport.

Fruit are typically harvested in early May, when ambient temperatures are lower. This is important, because after picking, the fruit can sit for two days in the field, before being moved to a packing facility and cooled, or picked and held for two days to allow for curing (sufficient time for ethylene to dissipate from the picking wound), before going to the pack-house. With an increase in temperature, fruit ripens earlier, and is picked instead in April – it extends New Zealand's market window. Although fruit is being picked earlier than it was in the 1970s, much of the infrastructure dates to the 1980s boom in kiwifruit, and is designed for harvesting in May. If cool stores are activated in late-March they have a lot more heat to remove from the infrastructure (concrete pads), so the energy costs for lowering the cool store temperature, plus the energy cost for lowering the temperature of a warm fruit in the cool store, are significantly higher.

The indications are that the temperatures we are experiencing at that time of the year are warmer. The effect of higher temperatures into autumn, and drought, also affect fruit quality. While not apparent in the packing process, port inspection has identified smaller fruit size, and sunburnt fruit, which has started the ripening process. Variable fruit sizes create issues in markets which are sensitive to a uniformly-sized product.

Irrigation in the event of drought imposes a cost not normally required in kiwifruit growing areas. Conversely, high rainfall creates micro-cracking on fruit, increasing water loss, and thus product failure or storage losses. Disruptions to transport to market also occur with high rainfall events, e.g., closing of the Waioeka Gorge disrupting access to port for international markets. The reverse can also happen, where climatic events reduce supply of food products in other parts of the world and New Zealand exporters ask growers to fill a supply gap.

Organisational capacity and capability

The capability and capacity to cope with climate change impacts and implications have several components: the presence of mechanisms/processes to manage risks, self-efficacy, the ability to access and mobilise resources to manage issues and how participants negotiate the challenges they face.

Capacity to deal with climate change-related risk(s) through risk management processes

The use of, and experience with, risk management processes ranges from formal, to semi- formal, to more intuitive experienced-based decisions. Formal processes consider risk in a highly-structured fashion using established policies and processes. Experience-based decisions are ones which were not articulated as risk management strategies, but are strategies to deal with problems as they arise based on past experience, local and historical knowledge, and often trial and error. Semi-formal represents a blend between these two.

In general, local government and large national/ regional businesses have more formal/semi-formal risk management processes, which they apply to critical aspects of their organisations. For example, the forestry sector uses a formal process for fire risk and response, and biosecurity issues (disease spread and monitoring sites for incursions). More semi-formal processes are used for other risks. As one forest sector respondent said:

> *Through experience we have learned that we need to site particular species in particular places and adopt particular regimes to mitigate the risk from snow damage – the same for wind exposure.* ***[Forestry sector respondent]***

Local government has formal risk-based management processes for several of their primary functions (flood, coastal, and asset management). These are underpinned by statutory requirements (under various statutes), disciplinary-based approaches (i.e., engineering practice), or approaches that are advocated in national guidance documents (e.g., based on national standards ISO 31000).

Small businesses (i.e., owner operators) and influencer groups tend to operate under less formalised and experienced-based risk management strategies, where knowledge based on experience in a particular area and an awareness of historical events, plays a significant role in their decisions governing how they undertake activities (See Box 9).

Box 9. Doug Avery: Lucerne case study

Doug Avery, an inspiring Marlborough farmer, dramatically revised his farming practices a few years ago in one of New Zealand's driest zones (annual average rainfall of 500mm). In the 1980s and 1990s, the farm experienced a succession of long dry summers that scorched the land. This forced him to look for alternatives. His farm, Bonavaree, is now a robust business that has doubled both its area and its production in the last decade.

The key to change has been drought-proofing the property with a plant called lucerne. In 1998, feeling despondent from years of drought, Doug went to a seminar about lucerne for grazing, presented by Lincoln University professor Derrick Moot. Lucerne, known in Europe and America as alfalfa, had been grown in New Zealand before, but many farmers had struggled to use it effectively. Once problems with managing the plant and grazing stock on it are sorted out, the advantages of lucerne become obvious. The plant sends a deep tap-root several metres into the soil, accessing moisture beyond the reach of other pasture species. Currently, around a third of Doug's 1500 hectare property is planted in lucerne, which, he says, is the key to sustainability for dry-land farmers. The lucerne means lambs can be weaned in early summer and brought up to saleable weights in half the time it takes most farmers. Doug has shown that using lucerne can result in a profitable farm without high investment in irrigation and the demand on water resources that implies.

In 2004, this led to a group of local farmers forming the Starborough Flaxbourne Soil Conservation Group, with the aim of arresting the environmental, financial, and social degradation in their farming community. Operating until 2008 with the support of the New Zealand Landcare Trust, the project transformed Avery's farm. Between 2008 and 2010 - the year Avery won South Island Farmer of the Year - Bonavaree doubled its output. Production doubled again between 2010 and 2013. Avery says that in the past decade he has turned back 30 years of landscape degradation, enhancing native plantings and fencing off remnants of native bush. He now shares his experience through talks to farming groups around the country, promoting farming practices that are high reward and low impact. "People coming to my talks expect to hear all about growing lucerne. Very few of them leave talking about lucerne. They leave thinking about how they might adaptively manage their farm businesses."

With the exception of local government, few considered climate change risk directly, instead they deal with elements pertinent to their industry or organisation; for example, drought management, invasive pest management, wind, or "it's not specifically associated with climate change, it's just that it's a function of ... a greater awareness of these risks" (forestry sector respondent).

Self-efficacy – confidence in the ability to act

How the risk is perceived, appears to have an impact on the management processes that are used; where the risk could have significant impacts on activities more formal process are employed, unless there is a belief in the ability to cope with a risk, in which case less formal process are used.

One respondent succinctly characterised the state of self-efficacy in response to a query about how the organisation was positioned to deal with climate change: "In some areas probably very well; in others – hopeless." This highlights the fragmented manner in which climate risks are managed within most organisations in the private sector,

Respondents expressed more confidence in their ability, or the ability of their organisation, to manage the technical aspects of climate change impacts and implications for well-described issues their organisations had past experience with, with risk management processes, or technical information and knowledge to draw upon. In particular, urban storm water, known plant diseases, and sea-level rise (See Table 5).

Table 5: Climate changes issues participants expressed a high degree of confidence in their ability to act upon

Private: Expressed confidence in their ability to manage the impacts and implications of climate change in areas that are critical to their business that they had successfully managed to date: • Electricity generators – wind and water; • Pastoral sector – drought and water issues; • Forestry – fire, disease, biosecurity, wind, and snow. Expressed confidence where research funds were invested to ensure long-term business viability. Initiatives include: • New kiwifruit varieties or new crops or stock-feeding systems.
Public: Local and central government confident dealing with: • High intensity rainfall in urban areas (Culvert sizes: "*If we are putting a pipe in the ground, pipes come at set sizes, so we might go to the next pipe size up.*" [District council staff respondent]); • Flooding through raised minimum floor levels in high-risk areas (through plans and policies); • Managing less frequent (1:100-year ARI) surface flooding through local education; • Managing flood protection and drainage schemes under the current climatic conditions; and • Managing sea-level rise in greenfield areas.
Influencers: Confident in ability to navigate practical issues as they arose.

Some local government participants highlighted a lack of basic localised technical data insofar as it affected their confidence levels. No or outdated LiDAR information, incomplete data for hydrological catchment modelling, and a lack of complete long-term monitoring data on which to explore changing trends were cited as examples.

All participants expressed lower levels of confidence in being equipped to deal with some of the poorly-described potential impacts and implications of climate change, and navigating social issues and debates. Commonly expressed sentiments, including "we have some thinking", "it's not quantified anywhere", "we just don't know", or "it will be very hard to manage" were used in relation to biodiversity, weed management, salt-water intrusion, habitat change, pollination changes, and urban or socially-complex issues like long-term adequacy of flood protection, shoreline armouring or drainage schemes, managed retreat from sea-level rise, and pest control. Urban areas were of particular concern due to the anticipated challenges of managing the human and technical dimensions of advising on necessary adjustments that go beyond incremental changes, and were highlighted by local government respondents as the most pressing area for consideration. Development and infrastructure expenditure are intensifying in major metropolitan areas at the coast, and the potential for increased rates of change has not yet been factored into planning. This was recognised by local government respondents who identified gaps in staffing capacity that would need to be addressed to enable this scale-up.

Additional gaps in capacity were exposed at workshop discussions with local government. The most prominent issues arising in the discussion were how to think about and approach changes in current impacts such as floods and coastal storms, and impacts where the risk will increase in unknown ways with sea-level rise and changes in frequency and intensity of precipitation.

A small number of participants had considered the complexity of changing risk, but identified a lack of capacity to deal with it. Other participants had not considered this challenge. As one regional council workshop participant said:

Consideration of changing risk hasn't permeated into the institutional response yet. [It's] a big job just to reflect [on] the current risk levels. There is a fear of moving too far ahead of reality.
[Regional council staff respondent]

Others just wanted access to experts: "[We] do not want another talk about climate change. Want to have one-on-one conversations with experts as applied to council problems."

Each council is at a different stage in considering climate change impacts and what to do about them. Tailored interactions to meet the needs of different knowledge levels, different stages in policy development, and different audiences were a strategy suggested for building capacity (See Box 10). For one local government respondent:

> *[The] top down process in councils [is] when a new issue comes, we go away and get expert information and study it and come up with some options, and go to the community – and they didn't even know it was a problem. Going with options is not taking the community along with you in a co-production model. If communities come with the problem, that's a good start for conversations about how to solve it. Communities need to be involved in the problem statement at the start and then solutions can be collectively developed.*
> ***[Regional council staff respondent]***

Box 10. Western Bay of Plenty: Not just a storm in a teacup process

Since 2011, Waihi Beach in the Western Bay of Plenty has frequently been subjected to coastal flooding, with significant and costly damage to private and public property. Western Bay of Plenty District Council (WBOP) and their community have been exploring and understanding the issues together. The first step for the council, and perhaps the most important one, was to agree what problem they were trying to solve. In February and early March 2014, council sat down with the community over a cup of tea. As council staff put it:

"Whether you've experienced flooding on your property or not, whether you live in Athenree, Pio Shores or down at the beach, you need to have a say. Whatever the solution ends up being, it will come from the community and it will affect you."

Eleven community workshops were held over this two-month period, leading up to the council's three-yearly Long-Term Plan (LTP) review in 2015. At this review, major funding decisions on a preferred storm-water option for Waihi Beach were to be made. Workshop attendees were asked to write down on Post-it notes what issues were created for the community/property owners when it flooded. Issues were grouped into themes: infrastructure, maintenance, regulation, planning, people and individual responsibility, funding, and finance. As the workshops progressed, the discussion moved from discussing impacts to identifying solutions. In this way, the voice of the community was heard and a process of deliberative democracy followed by generating the framing and focus of the LTP. The positive outcomes of the consultation were community buy-in, raising community interest, generating a sense of council-lead community empowerment, and education in the wider community on coastal flood issues. The process also allowed the council staff to tap into local knowledge and "reality check" elements of the LTP, before it went to the full council for deliberation.

Ability to mobilise resources

Resources to deal with climate change appear to fall into several broad clusters along a spectrum:

1) Organisations where the majority of skills and resources are available in-house. These organisations often have multiple goals or responsibilities, as well as research, applied, and management aspects to their functions. Although expertise may exist within different parts of the organisation, they can be accessed as needed. However, the integration of knowledge and ability to deal with issues can be inhibited by organisational or disciplinary silos which could lead to climate change matters sitting in disconnected areas of work and lacking a holistic focus. Internal organisational networks are important. Extra knowledge is required periodically around a diversity of issues and acquired through participating in research, contracting defined pieces of work, or using personal networks. Local and central government typically populate this group.

2) Organisations where the in-house skills are primarily around applying the science/knowledge to or managing a particular context. In such organisations there are usually a small number of employees focused on climate change related issues, they often exist in isolated small groups focusing on a specific function of normal operational importance; for example, sector- or region-specific climate modelling. This group is more likely to include private or industry organisations (electricity generators or forestry organisations) and smaller councils. This type was described by one respondent as follows: "Many councils [are] lacking in time to get into these issues - if they have a staff of only two. [The] majority of councils are like that really." [District council staff respondent]

They fund particular defined pieces of work to meet specific needs, depending on need and organisational priorities. Personal networks are likely to be important.

3) Organisations where the technical skills may be low, but the applied skills are high. They often do not have the resources to contract additional knowledge, but rely on personal networks and connections to access and build knowledge. Usually influencer groups, and typically community-based organisations; for example, restoration or local Coast Care groups.

Capacity and capability challenges

Participants describe a number of other challenges which affect their capacity and capability to deal with the impacts and implications of climate change (Table 6).

Table 6 – Key challenges affecting the capacity and capability to manage impacts and implication of climate change

Personal networks	*"Personal networks are affected by organisational restructuring and retirements, which makes it more difficult to obtain key knowledge." [**Central government agency respondent**].* Diminished personal networks due to staff changes affect the flow of information in and across all organisations, with broad implications for integration and coordination of climate change responses.
Reliance on external sources of knowledge and information	Additional skills are often required to fulfil essential functions. *"Being a relatively small organisation with not many technically-abled staff, our ability to actually assess what's going on is a bit limited." [**Forestry Agency**]* *"We don't do the research ourselves, we just can't. We have to rely on external agencies." [**District Council respondent**]. However, the budget available for consultancy work to fill council knowledge is low." [**District Council respondent**].* This means that critical pieces of information are either not secured or their acquisition is postponed.
Low priority	Climate change related work or projects are often low priority; for example, *"Other work takes priority." [District Council respondent].* In addition, there could be competition with other more urgent issues: *"We need the ambulances at the bottom of the cliff now, so we can't be thinking about what ambulances we need in fifty years because we're just so busy."* and *"How do we build in recognition of long-term multiple issues like climate change into those management priorities?" [**Conservation manager**]* Consequently, climate change related decisions, strategizing, or knowledge acquisition are postponed.
Lacking critical skills	In some cases there is a skill shortage in a particular discipline either within an organisation or at the national level. For example, *"[It is] difficult to employ and retain hydrological modellers as there is a shortage of skills and high levels of demand for water allocation projects across the country at present." [**Regional council scientist**].* Impending retirements coupled with a low level of recruitment means there *"is a risk coming up for the industry that we're losing that institutional knowledge" [**Regional council scientist**].* In the absence of key skill sets, the ability to translate and assimilate knowledge regarding climate change into organisations in a way which generates meaningful responses and strategies is impaired.
Fragmented view of climate change	Climate change is still viewed and responded to in a fragmented way. To address this requires *"systems thinkers who are thinking quite laterally in a joined-up way" [**Conservation manager**].*
How to translate from science to on-the-ground change	Individuals and organisations to translate science and policy into *"what does this actually mean to me on-farm" [**Land-care agency respondent**]* is a necessary, but often missing, function taken on by influencer groups. Without this translation function the gap between science and knowledge and on-the-ground action, change, and/or adaptation is maintained.

Local government staff respondents highlighted a legacy of bad feeling about the legal back-end approach, stating that there is a growing recognition of the need for a new class of experts – social process experts – with the skill to work with decision makers and communities towards collective outcomes. This will require some smart ways to communicate and share knowledge and the leadership skills to do so.

In summary, ways of managing risk vary from formal and semi-formal risk management process to approaches based on past experiences. Most risk management processes and practices were linked to specific issues, e.g., fire risk, rather than climate change.

The more undescribed or complex the impacts and implications of climate change were perceived to be, the lower the levels of confidence participants expressed in coping with these issues. Urban storm water, known plant diseases, and sea-level rise were considered to be understood and manageable, while biodiversity, weed management, salt-water intrusion, habitat change, pollination changes, and urban or socially complex issues like the long-term fate of flood protection, shoreline armouring, drainage schemes, managed retreat, and pest control were less well understood. Urban areas were highlighted as of particular concern, where climate change impacts and their implications were the least well understood.

Organisational capability falls along a spectrum depending on size and focus, degree of integration of functions within agencies, and across governance levels. Key capacity and capability challenges include diminishing access to knowledge and information due to organisational restructurings and staff turn-over, reliance on external information, low priority of climate change compared to other more immediate risks, lack of some key skills (hydrology and coastal management with climate change experience), fragmented approach to climate change, lack of translators/ boundary agents between science and on-the-ground change.

ENGAGING WITH CLIMATE CHANGE IN DECISION MAKING

Barriers to climate change in decision making

The analysis of interview transcripts and local government workshops revealed 43 distinct and unique barriers to decision making. Together, these were mentioned over 100 times. These distinct barriers have been organised into five types that best fit the emphasis, language, and examples respondents described as influencing their decision making: governance and institutions, policy arrangements, uncertainty, resources, and psychosocial factors. Private, public, and influential actors placed varying degrees of emphasis on each of the different barriers, according to their affiliation. Some barriers are also more important than others. Governance and psychosocial barriers created the largest impediments to effective decision-making relating to climate change impacts and implications.

Table 7 identifies each of the barriers mentioned. These barriers refer to decision making in response to a range of climate-related risks, and not a single risk or climate change exclusively. In some cases, respondents describe barriers to effective decision-making relating to the *implications* of a changed climate; for example, a change in the distribution of certain pests or disease, and elsewhere, identifying barriers relative to direct impacts, such as an increase in precipitation.

Table 7: Barriers to climate change in decision making, grouped by theme

Governance and Institutions	**Policy**	**Psychosocial**	**Resources**	**Uncertainty**
A lack of clarity on roles and responsibilities across levels of government	Lack of clarity on liability for decision making	Public disbelief in the science of climate change	A lack of staffing, skills, and expertise - particularly in local government	Uncertainty about climate impacts
A lack of clarity on roles and responsibilities between the public and private sector	Lack of certainty around compensation and injurious affection	The contested nature of climate change science which creates a 'mandate' barrier	The cost of implementing adaptation actions	A lack of data at local and regional scales
A lack of leadership by central and local government	Weak planning legislation unable to control development in high risk areas/areas at future risk	The tendency of people to discount future benefits	A lack of access to funding	A lack of confidence in climate change projections at a local level
A lack of leadership from organisations and businesses	The focus on mitigation has been a barrier to accepting adaptation/conflation of mitigation and adaptation (experience with Emissions Trading Scheme)	An emphasis on the individual rather than the community	The capital costs of engineering solutions	A reliance on historical data and experience
A lack of coordination between central and local government	Insurance policies are unclear	A lack of public understanding about the levels of risk that they face	Constraints on the efficient use of capital for adaptation	Information not directed at specific audiences
Competing demands between the public and private sectors	A focus on disaster recovery rather than disaster prevention	Cultural resistance to change	Low returns and limited markets for investment (e.g., carbon credits)	Information is not relevant to many people
A mismatch between the time horizons for adaptation and political and management practices	A lack of consideration of equity in current policies	The adversarial nature of New Zealand politics	Competition for resources (e.g., funding)	A lack of standards for interpreting data reliability
Inconsistency in standards and policies across jurisdictions		The 'desirability' of living in high-risk areas (beachfront, flood plains)		
Difficulties in trade-offs between policy priorities		Apathy and issue fatigue		
		A fear of the unknown, resulting in denial		

Governance and institutions

Governance is used here to describe barriers relating to the governing processes that guide and steer decisions about climate change impacts and implications, including institutional arrangements. Policy barriers, on the other hand, are those related to outcomes of decision processes.

The most frequently cited governance barrier is best described as a mismatch between the time horizons for adaptation decisions and political and management practices. For the private sector, the mismatch was most closely related to investment choices. Changes in climate, for example, are likely to result in changes in the distribution and extent of pests and diseases that will impact primary activities such as forestry. Recovering and replanting of an affected area would be a multi-decadal investment, during which time not only would the climate continue to change, but other unforeseen social or economic constraints might emerge. Considerable uncertainty about both future impacts and implications of climate change, as well as uncertainty about future economic and political constraints, compound these barriers. The price of carbon, the Emissions Trading Scheme (ETS), and managers' tolerance for risk can all play a part.

Other private actors, such as in the kiwifruit industry, recognized the importance of addressing this mismatch between decision-time scales and climate impacts, and had begun to put contingencies in place. For example, some growers were already putting water-harvesting dams in place to deal with anticipated future water shortages.

Local government staff and elected respondents also identified mismatched timescales as a barrier to decision making. Some statutory instruments may have much shorter or longer process and response times, creating contradictory outcomes. As a way of addressing different time frames of activities, one staff respondent reminded a workshop that under RMA section 32 assessments, "information around the costs of not acting should be included in options put in front of the decision makers" for regional and district policies and rules.

Local government also highlighted the need for better coordination between agencies for infrastructure and development decisions that could be addressed by greater leadership on climate change from central government. One interviewee said, "In terms of that leadership role, I think it probably does need to come from some sort of central government." Without

One of the real challenges for forest owners is the long investment cycle ... while it sounds really good in theory that you would make a decision to re-establish [trees] based on your forecast of what climate change is going to do to the site, in reality there are other constraints that would probably force your hand.
[Forestry industry respondent]

strong leadership on climate change, many in local government felt they were either left to 'muddle through' on their own, or working against central government. A local government staff respondent described the situation in the following terms:

I know the Parliamentary Commissioner for the Environment put out a recent paper on climate change, and I believe that there's more work happening around that. I'm really hoping that will give us a much stronger mandate to stand up and say, 'You know what? Something needs to be done about this.' There [are] a lot of national conversations that need to be had, which will then make it easier for a regional council or local council to actually stand up. At the moment, you feel a bit like you're pushing against government policy in some areas.
[District council staff respondent]

In statutory terms, local government respondents, reflecting the perceived need for greater alignment, also frequently mentioned "linking hazards and climate change planning".

Related to this mismatch, both the public and private sectors described a lack of clarity about roles and responsibilities for climate change decision-making. This was despite devolution of much of the responsibility for addressing the impacts and implications to local government. This highlighted the need for a much more coordinated response between agencies and levels of government.

The comforting thing from my perspective is that we are girding our loins for it, but it's trying to create that urgency in other agencies where we know that there's going to be an impact ... We can get our own ducks in a row, but actually we're reliant on other agencies to do the same.
[Conservation manager respondent]

A lack of coordination and a need for more 'linked-up' thinking across levels of government were also described in the context of the National Infrastructure Plan:

> *These people ... are roaring ahead with a 30-year infrastructure plan and the point I made is nowhere in here do you talk about resilience of infrastructure and ability to have a managed retreat or to build to a different standard. That's one of my frustrations: I don't think the ministers get it sometimes ... I just don't think they understand if they set their standards for infrastructure what that means for local government ... It's just sometimes not always joined up.*
> ***[Regional councillor respondent]***

Local government staff respondents were concerned that, without properly accounting for climate change impacts and implications, decisions made now may lock communities into maladaptive pathways.

Institutional arrangements can also act as barriers to more effective decision-making. Respondents distinguished between institutions that can address developments in "greenfield" sites from those where there are existing uses. In distinguishing these, they noted that "new institutions are required" for transitioning existing uses from areas that cannot be feasibly or affordably 'protected', for example, from sea-level rise. New funding mechanisms might be required not only internationally, through proposed loss-and-damages arrangements for nation states (Roberts et al., 2015), but also locally and regionally. Additionally, land to retreat to would also be required.

Institutions of practice also affect the private sector since they set the operating environment for many land- and water-management decisions. For example, both kiwifruit and merino wool industries were very aware that changing climate risk could increase their place-based exposure to climate events and changes in climate variability could potentially disrupt their business operations. Decisions by public agencies relating to flood protection, road maintenance and construction, energy infrastructure, port access, and biosecurity threats all have flow-on effects for private sector decision-making. However, there was only limited evidence of joined-up thinking about these dependencies (see Box 8).

Policy

Policy barriers are distinguishable from governance barriers insofar as they are outcomes of the governance processes. Impediments arising from existing governance and institutional arrangements and associated regulations and laws were identified. In some cases, such as for the kiwifruit industry, policy barriers arise from legally-mandated management structures as well.

Several of the policy barriers identified are directly related to governance barriers. For example, a lack of leadership on climate change, as well as a lack of clarity about the division of responsibility for dealing with the impacts has resulted in a weaker mandate for councils to control future development in high-risk areas. In some cases, "councils have been forced in some ways to allow marginal land to be developed. I'm talking about marginal land that's got a high propensity to flood". In these cases, respondents described how developers have pushed for fewer restrictions, and taken their submissions to the Environment Court and won; noting that as long as banks and insurers are willing to underwrite a mortgage or insure a property, people will continue to build in 'at risk' locations.

Respondents in the local government sector highlighted that a continued focus on disaster recovery, rather than reduction of risk, is a barrier to considering climate change impacts over longer time frames. They noted that while recent experience with climate-related hazards has raised awareness, it is likely to be temporary as memories fade. The focus in many jurisdictions on recovery following a disaster, was described as diverting the small capacity available for longer-term planning or developing risk-reduction measures.

A significant barrier to considering climate change impacts in the primary industry sector was the significant opposition to anything to do with climate change. This stems in part from efforts of past governments to reduce GHG emissions, which was perceived by the pastoral farming sector as unnecessary and punitive. The net result is that many in the sector now conflate mitigation and adaptation.

> *I was at a farm recently... and he was actually talking about Al Gore and climate change and saying how he was, you know, completely against the whole concept for a start. So, that's probably the only type of conversations I've virtually had. But not people proactively thinking, 'Well, if this is something that's going to continually change ... [we need to be] prepared for that.*
> ***[Dairy farming advisor respondent]***

However, such views were not consistently held across all primary sector respondents. For example, the beef and lamb sector had a more nuanced appreciation of the effect of greater climate variability and how that needed to be considered in their industry, while the kiwifruit industry understood the significance of interruption to their value chain from increased frequency of damaging storms on product and market access.

Without a strong message from sector leaders, as well as central government highlighting the challenges associated with future climate change, planning in the primary sector may well continue to fall behind.

Psycho-social

Governance and policy barriers account for over a third of the impediments to more effective climate-related decision-making. Barriers related to psychosocial barriers associated with non-material issues include perception and understanding of risk, culture, and cognition. Nearly all of the respondents described barriers of this kind and the inability – or failure – by individuals and organisations to undertake long-term strategic planning. The second largest cluster of barriers related to scepticism about the science of climate change or its impacts.

One respondent said they struggled with decision making for climate change, given the long-term horizons to consider:

> *In most of the agencies I've ever dealt with, there's a very obvious lack of long-term thinking and long-term strategies. I think that's human nature; we live in the now. As much as we like to think that we're forward thinkers, we're not. And certainly getting the momentum for strategic planning a hundred years down the track is pretty much impossible I think.*
> ***[Conservation manager respondent]***

Part of the lack of long-term thinking about climate change was related to what respondents described as considerable scepticism in the public and also, in some cases, amongst elected representatives. This made it increasingly difficult for them to gain support for more strategic decision-making.

> *When it comes to climate change, it's been proven. So, from an organisation that is legally required to deal with the impacts or the effects of climate change, i.e., the adaptation of it, it's not helpful to have the debate in the general population, because that's who we work for and that's where we source our elected representatives from.*
> ***[Regional council resource manager respondent]***

For local governments mandated with responding to the impacts of climate change, this scepticism created a 'mandate' barrier, which made it difficult for councils to take action. A respondent talked about the standards used in the regional policy statement to account for sea-level rise, and the pushback from councillors:

> *We were using a metre in our regional policy statement and we got challenges from five councils as a consortium. They basically challenged the numbers and said, 'No, no, it's not happening. It might happen in other places, but we've got information to show that a one-degree rise over the last century hasn't occurred in our area, therefore climate change doesn't occur in our area' – this sort of thing.*
> ***[Regional council staff respondent]***

This was echoed in the conversation with another local government respondent who said that:

> *For our councillors, for example, who are decision makers for this district, climate change is almost like a dirty word... You know, if you want to have a sensible conversation, say, at a council workshop, well then, you know, these councillors immediately jump on you, 'Where's the evidence?'*
> ***[Regional council staff respondent]***

Faced with internal opposition to climate change science, implementing longer-term strategic plans to reduce vulnerability are often unsuccessful. As long as the science appears to be 'unsettled' or open to debate, and in the absence of a clear message from central government, local governments face an uphill battle.

Furthermore, for public sector actors, climate change was often described as one of many issues they were facing. It was "in the background buzzing faintly. You have to think about it, but it's kind of a way off". It wasn't the most pressing concern. As one interviewee from local government said, "I think local authorities still see it as being something that's going to come some distance in the future."

Misinformation was also a barrier. In an interview with a forest industry representative, when queried about managing for the anticipated effects of climate change, the respondent stated that:

> *We are just managing on a status quo type basis, and if we get some climate benefits that will be well and good, but if we don't, we're not really expecting or counting on it. I see recently they are predicting a mini ice age somewhere in a few years that might be cooling things down rather than warming us up. You just don't know.*
> ***[Forest industry representative respondent]***

Concern about apparent apathy about climate change was referred to as another issue, it was "off the agenda" as one private sector respondent noted: "It [climate change] just seems to have gone off the agenda. Water's still on the agenda, maybe there's a couple of other environmental issues. But where really is climate change?"

Finally, there is also a cultural barrier to decision making; the "can-do" or "she'll be right" attitude of some New Zealanders when faced with climate extremes. For example:

> *It's also an element of stubbornness, you know that attitude. 'I'm not going to let nature dictate to me, I can control nature. I'll dig some more drains; we'll be fine.' That's quite the strong sentiment in some places.*
> ***[Conservation manager respondent]***

While some councils have been making recent progress, as reported by the December 2015 local government workshop participants, they also reported that there are significant challenges to implementing policies and practice on the ground that are associated with the psychosocial barriers to understanding the nature of the problem.

Local government respondents emphasized psychosocial barriers the most. They were the least important barriers for the influencers and only of middling importance to private sector actors.

Uncertainty

A lack of information, or uncertainty (rather than outright disbelief), was identified as a barrier. Respondents described uncertainties about climate impacts – particularly at local and regional scales – as further barriers to decision making.

> *Getting the momentum for strategic planning one-hundred years down the track is pretty much impossible... and maybe that's to do with the fact that people are still not very comfortable about what it means, you know, what does it [climate change] mean, and what are we planning for? Because it's a constantly changing risk.*
> ***[Conservation manager respondent]***

The difficulty in determining the effects of future climate change was also noted as a barrier by private decision makers, and used to justify inaction. "Trying to predict climate change is just grasping at straws," said one farming industry respondent, who indicated that other, more quantifiable risks such as supply and demand were more likely to influence planning and management choices.

Uncertainty was also cited as a barrier in specific contexts where information needs pose a challenge to decision making. For example, at a regional scale there is still very little known about the potential effects of climate change on local wind patterns. Complete LiDAR coverage of New Zealand would enable additional modelling of regional predictions of wind patterns, which could support primary industry adaptation planning in particular.

Uncertainty (perceived and real) about whether climate change is happening and where the uncertainties lie, was cited as affecting the confidence of decision makers to act and whether any adaptation would be effective and necessary. For example, "The precipitation range [from the MfE guidance] in Taupo

is 16 to 28 percent, [you] can't make a million-dollar decision on that." [Electricity sector respondent].

Respondents called for methods for dealing with uncertainty, especially in contexts where the ability to quantify an impact may never be forthcoming, due to the complexities involved and the lack of science understanding.

Resources

Across the interviews, resources were cited as another major barrier to decision making. 'Resources' includes money (typically funding constraints), technology, capability and capacity. For agencies, such as the Department of Conservation, tasked with managing large areas of land, or local councils, a lack of funding was often given as an example of a resource-related barrier. These agencies were barely able to keep up with existing monitoring of invasive species and pests, let alone keep track of emerging ones.

For councils, human resource capability was an issue. While some councils provided extension and outreach – particularly to the primary sector – others were unable to. Given that farmers and other primary producers are likely to be among those affected by climate change, and also – as a segment of the population – some of the most sceptical about its impacts, this was an issue of concern.

> *At [Regional Council] a lot of those farms were visited every year and we had ... a rural advice team that was doing the equivalent of what I do, that was there to help suppliers too. [Another Regional Council] doesn't really have that service and to be fair, you've got farms that have never seen the council for ten-plus years and they finally get an inspection now.*
> ***[Regional council soil conservator]***

Additionally, ensuring that all council staff were sufficiently resourced in terms of the science regarding impacts and implications of climate change, was another barrier identified by respondents.

> *All staff – all permanent staff – in regional council, they need to be well informed about the [climate change] debate and people who come up with the plans and that type of thing, have input into that.*
> ***[Regional council staff respondent]***

For the private sector, the resource-related barriers to the opportunity costs associated with climate change impacts were highlighted; for example, the investment cost of replanting or changing tree species for commercial forestry.

Capital investment costs were not only an issue for the private sector. With climate change expected to have significant effects for infrastructure planning, local and district councils, as well as municipalities, are facing increasingly costly decisions about future-proofing vital buildings, roadwork, and protective structures.

Resources were mentioned least often by influencers, but were among the most important barriers identified by local government and private interests.

Lack of access to information

Information can be inaccessible or restricted. One regional council respondent noted that information needs to be located where it can be used when it is needed. Another noted that current generic information isn't being used, as it is incomplete and not detailed enough and that the latest science needs to be effectively communicated and disseminated. Respondents across all groups suggested there was an urgent need for standardisation of climate change guidance and its use across New Zealand to give a sense of policy certainty. They also suggested that information on climate 'events' should be centrally located and accessible for those making decisions in the public and private sectors. Each council doing these things themselves was regarded as an inefficient use of resources.

There was also a lack of long-term information. Current monitoring systems for determining priorities and preparing strategic responses were seen as inadequate, particularly by public decision-makers. One council respondent described the situation as "ambulances at the bottom of the cliff" - responding to climate-induced crises, rather than having access to information from long-term monitoring programmes. Long-term monitoring is vital, but is often at risk due to short-term funding cycles, shifting priorities, and low visibility in terms of return on investment. Council respondents wanted to see re-design of current monitoring frameworks to meet information requirements of climate change risks and impacts. They also indicated that they needed to be able to answer key questions regarding vulnerability and its drivers, such as changes in land use or management practices that were creating new risks or exacerbating existing ones.

Perceived lack of political will and relative importance of climate change

Central government was perceived as being reluctant to engage on climate change and New Zealand was considered 'immature' with respect to climate adaptation. Councils observed a lack of political traction. For example, current negative environmental effects, such as wilding pines, will get worse under climate change, but current control-option plans are not successful, even though it is cheaper to solve now rather than later.

Private sector respondents noted that while climate change information is needed, there are other issues that affect their businesses more significantly than climate change. Electricity generators and transmission company respondents noted that big changes in their business environment grab board-level attention, and that their critical analysis systems can work with the climate changes envisaged within the current operating tolerances risk profiles that can be managed.

The perceived lack of priority given to climate change by government was described as creating a lack of incentive to adapt combined with a lack of understanding of the options available and their effectiveness. Access to adaptation finance was highlighted as a barrier and respondents showed a lack of knowledge of how to develop robust options. Due to a perception that the impacts of climate extremes cannot be managed, investment in risk and impact assessment has been limited. These barriers in turn appear to be leading to the potential for maladaptive options; for example, changing forest tree species to eucalypts may be an adaptive response to water and temperature stress, but may significantly increase production loss due to increased risk from pests.

Critical leverage points

The research also asked how the adaptive capacity of governments, business, iwi and communities could be enhanced to incorporate the implications of climate change. Research participants identified a number of barriers for achieving this but also a number of enablers and entry points. Levers for change to overcome the previously identified barriers are presented below.

There was widespread agreement amongst respondents that greater integration was necessary across governance levels and between sectors in order for climate change impacts and implications to be routinely considered in decision making. Several areas were targeted for attention:

- Better linkages between statutory instruments;
- Taking opportunities presented by policy reviews and legislative reform;
- Taking opportunities when climate events occur for changes in practice;
- Considering how the financial sector can motivate change through changed banking and insurance policy settings;
- Using peer sharing of information, supply contracts and boundary organisations to leverage changes in practice;
- Examining innovative new land uses that may be less vulnerable to climate risk than existing ones;
- Using NGOs (e.g., coast care and land care groups) as entry points for change;
- Using new smart tools to change planning practice from time-constrained approaches to adaptive approaches, which are more effective at policy integration;
- Greater attention to community engagement to better understand climate change risks and the values of communities;
- Shifting from gaps in science, to policies that enable implementation; and
- Designing regional planning on a rolling basis, so no 'start and stop'.

Whilst these were commonly suggested levers for change, public, private, and influencer groups each had different foci.

Public sector

Decisions by public sector agencies are primarily motivated by the governance and institutional context within which they operate, i.e., the statutory mandate and the norms and rules of engagement in particular professional disciplines and associated functional areas. Amongst those agencies with responsibilities for reducing the risks from climate change impacts – primarily at local and central government levels – there is fragmentation, and some policy settings that are not aligned in law and in practice. Respondents described this as inefficient and a hindrance to effective responses to climate change impacts, due to each unit of local government and functional area

addressing climate change impacts, with some exceptions beginning to develop.

There is no integrated package of policies and measures for driving management of climate change impacts. This means that integration efforts are often ad hoc and piecemeal, done by individual councils, and at a greater cost than a more integrated approach. Attempts to successfully navigate through many governance levels have not worked well, except in a few isolated cases where integration has come from a unitary governance arrangement or through joint council committee processes (Tasman District and Hawke's Bay are examples). In such cases, several different levers were used.

Several councils have successfully used the Environment Court to support their attempts to implement coastal management plans that were designed to reduce hazard risk, including climate change impacts from sea-level rise. Cases where this has been successful were driven off the New Zealand Coastal Policy Statement (NZCPS), given policy support through a Regional Policy Statement (RPS), and implemented through policies and rules in District Plans, or in some cases through Regional Coastal Environment Plans. While district councils have no authority to cancel existing use rights through district rules, regional rules can, so the emergence of rules in regional plans provides a more significant capability in coastal management. The high level NZCPS has been effective in encouraging flexible responses to increased coastal hazard risk and has begun to discourage static measures that increase risk and lock-in asset exposure.

Other attempts have been more nuanced at central and regional government level where climate change implications have been included in natural resource management strategic and decision settings, framing climate change as a risk issue. For example, facilitating discussions of where on a continuum of impacts each interest group would be affected by climate change (See Box 11).

Regional councils and some large cities have been proactive in sharing information and practices across New Zealand as they relate to natural hazard risk and climate change impacts, as opportunities arise from plan preparation and the 100 Resilient Cities programme[13]. Boundary organisations bridging the science policy divide have been successful, especially due to a focus on the decision relevance of the information and the tools used.

Box 11. Strategic climate change: Conversations on adaptation planning

In 2014, New Zealand and Australian researchers documented the relationships between weather and tourism activities in the Queenstown-Wanaka region, South Island, New Zealand. Scientists expect that the weather conditions natural resource-based tourist destinations rely on are likely to be affected by climate change, but current understanding of how businesses and destinations manage for present and future conditions is limited both internationally and in New Zealand specifically.

Key stakeholder interviews and a workshop formed the basis of the work. The researchers used ideas around coping ranges, derived from ecological management literature, to develop a framework to understand and inform thinking and strategies on how tourism businesses and destinations are currently responding to the weather and perhaps could in future respond to climate change.

Results of the research showed that within a particular destination – in this case Queenstown – individual businesses have widely varying relationships with the weather, with each type of activity operating within its own coping range to particular environmental conditions; for example, temperature. Coping, which can be observed outside the 'ideal' range of a particular environmental condition, requires business adjustments, so as to cope with increasingly extreme conditions up to a critical threshold point. The findings also suggested an increased need for more planned adaptation measures as these would be necessary to increase viability under increasingly extreme climatic conditions. Conversations at the Queenstown workshop indicated that at and beyond thresholds, keystone industry and destination level strategic adaptation planning is required to ensure the viability of the destination as a whole.

[13]http://www.100resilientcities.org

Some suggestions were made by local government respondents for improving the type of information needed to address climate change impacts:

- Increased networking across councils and the means to do so;
- Information that is in an updateable form and that is lodged in a place with easy access (digital form);
- The capacity to access a 'state of the nation' on adaptation practice and new science that changes policy settings;
- Mechanisms to share outcomes from international research endeavours and made relevant to New Zealand decision settings;
- Specific information in infrastructure replacement innovations that could offer practice consistency;
- Documented case studies nationally and internationally;
- A communication focus on the benefits of undertaking adaptation actions to take the focus away from the short-term costs; for example, a nation-wide education campaign about climate change impacts to foster better understanding of the issues;
- Information on time-based planning with emphasis on the lifetime of land uses and activities, as well as information on the impacts of climate when it is outside lived experience to adapt;
- Use of scenarios; and,
- Working with communities to identify what they value and what is at stake.

A shift in focus to the long-term objectives in the RMA, NZCPS, and other NPSs should enable a focus to develop away from local issues and private interests. Community engagement can play an important role by enabling councils to understand what values and cultures drive communities and potentially reduce tensions between the different interests.

A common theme coming from local government practitioners was the need for a more participatory decision-making model dealing with long-term changing climate risks. While participatory democracy is gaining currency, there was an expressed need for a clear and consistent framework for its implementation so that consultation can shift towards an engagement model.

There was confusion about which information has legitimacy and how it is communicated and by whom.

Some local councils are still framing climate change as a 'belief', so people aren't 'convinced' which has a delaying effect on addressing impacts and their implications. To overcome this framing, councils wanted simple clear stories about consequences, long-term physical and fiscal risk, and limits to 'protection'. Using council case studies in particular locations was seen as helping dissemination of information on what their peers were doing. Experience in the flood management area was suggested as an example of practice that builds good community relationships. The role of personal connection was seen as an important way of bedding in engagement. A council respondent summed this up in the following terms:

Socially constructed understanding is crucial to embed experience.

Private sector

In some industry sectors, current climate variability is prompting greater consideration of responses to climate change. For example, in the kiwifruit industry loss of winter chilling is leveraging a change towards selecting varieties with a 20-year patent life; a tacit admission that breeding programmes will change to accommodate new climate conditions. World Bank forecasts of climate change impact have influenced how the private sector manages risk through its investment decisions, e.g., using carbon foot-printing. The forestry sector is aware of which tree species can withstand higher wind speeds, and the influence of topography on wind speeds, and thus the susceptibility of trees to damage. The pastoral farming industry, including beef and lamb, are investigating fodder crops that are more sustainable in drought conditions, identifying at-risk land, and focusing attention on mitigating run-off and risks to waterways.

Many private sector respondents felt that keeping issues in front of people and having reputable peers and others speak about the need for change was also an important lever for change. This "leading by example" is proven practice and widely appreciated in the agricultural sector. Industry leaders were often cited as critical for leveraging change at a sector level (e.g., the CEO of The New Zealand Merino Company initiated discussions with CEOs from the agricultural sector to work together to increase the value of outputs and manage the potential impact of climate change on sector exports; and other individuals initiating national roadshows on new farming approaches [see Box 9]).

Using supply contracts to leverage change was referred to by several primary sector respondents. The merino industry, for example, uses care for the environment as a branding mechanism for its high-grade wool; while the dairy industry relies on monetary sanctions for environmental harm and uses those funds for clean-up purposes.

The banking sector identified a need for better data on climate risks to inform the banking markets of risks to their investments. The insurance industry is also starting to request information about hazard risk, the effects of which are already reflected in product pricing. This will continue to act as a lever for change, albeit indirectly.

Influencers

The role of influencers in the community was often cited by respondents as critical to leveraging change that considers climate change. Universities, industry leaders, NGOs, and key individuals were at the heart of many examples given that had leveraged climate change considerations. Community-based projects that brought a number of different interests together to solve a particular problem were described as good places to start. For example, at the regional level there were examples of influencers working closely with regional councils to trial innovative approaches for buffering coastlines, designing management strategies, or instituting new land uses to mitigate flood risks in low-lying areas. Such examples often worked best where there was a public agency partnering with landowners, NGOs, and/or, in some cases, with research organisations.

The role of universities in providing solutions to intractable problems, like freshwater management, was cited as an important leverage point for greater attention to climate change impacts. The Chair of Lakes Management & Restoration at the University of Waikato was influential in the Rotorua Lakes clean-up, for example. The role of dune groups was another that is changing community attitudes towards the impacts of sea-level rise.

*We put about half a million bucks a year into Coast Care, which is this dune restoration programme. You know that if you can use a soft natural barrier with its ecological and societal values then that's much more preferable than substantial hard engineering or a retreat. [**Regional council staff respondent**]*

The influence of university climate change research projects focused in communities was viewed as helpful for leveraging change towards more flexible and adaptive land-use practices. Good engagement and communication with researchers embedded in decision processes were highlighted as important levers.

Looking for alternative land uses that have commercial potential in low-lying areas was suggested as a way to leverage change. For example, wetlands and flax farms for tourism and educational purposes were cited.

Iwi and existing community-based groups managing estuaries, wetlands, indigenous forests, pest control, and conservation were seen as influencing and informing councils about impacts of climate change. A good example where a community group influenced a jointly-funded water-quality restoration and protection programme is the Rotorua Te Arawa Lakes Programme (Box 12). Such community-based groups have networks for informing their members and the wider community, which is illustrative of channels that were highlighted as having potential for building greater awareness of the implications of climate change.

Central government agencies also suggested the potential to develop a series of positive relationships with community groups including, for example, the Forest Restoration Trust and a number of iwi groups just coming though Treaty settlements. These types of groups can use conservation and environmental projects that can be guided to manage land to accommodate for the impacts of climate change. Other potential levers for change identified by influencer groups included the role of the Landcare Trust work with farmers, who could become climate change champions using success stories with their peers across farming communities.

Box 12. Rotorua Te Arawa Lakes Programme and the role of the Lakes Water Quality Society

The Rotorua Te Arawa Lakes Programme is a partnership between iwi, Rotorua District Council, the Bay of Plenty Regional Council and central government that formed to implement a major lakes restoration and protection programme for the Rotorua Lakes. The Lakes Water Quality Society (LWQS) is a community organisation focusing on water quality improvements in the Rotorua Lakes. Their activities include fostering research and education on lakes issues, and working with local and central government and community groups on restoring the lakes to health. The mission of the LWQS is to remediate those lakes that have deteriorated and prevent the lakes from further harm.

The Society played an important role in mobilising robust science about what was happening in the lakes. This knowledge was disseminated through eight symposia over 12 years to stimulate ideas about how to fix the deterioration of the lakes water quality. LWQS helped to persuade government authorities to act, and to fund and execute remedial work. Major components were sewerage reticulation and treatment, engineering works, better farm management in lake catchments, and changes in land use.

*"To our surprise some lakes responded very quickly and in a few years water quality greatly improved. Work is underway or planned for most other lakes." [**LWQS member**]*

Channels that LWQS used included lobbing local councillors, making presentations in various fora and making submissions to Annual Plans and Long-Term Plans. The developing science confirmed that enrichment by nitrogen (N) and phosphorus (P) compounds from human activities caused most of the lake problems. By the early 2000s, all the easier measures had been implemented: fencing cattle away from streams and lake margins; planting to stabilise erodible stream banks; and dealing with effluent flows from dairy-farm milking premises. The further measures needed were substantial and expensive: reticulated sewerage for communities around the lakes; engineering works like the Ohau Diversion Wall; control of precipitation of P from some lakes and streams; adoption of best practice in nutrient reduction by farmers; and changes in land use from farming to forestry.

The solutions required bigger changes; major investment and changes in public policy were required. Interventions were discussed by Working Groups, and formally approved by the Strategy Group and by the two local authorities (Rotorua District Council and Bay of Plenty Regional Council) who carried out the programme. The first of the new major measures put in place were the Mourea / Okawa Bay sewerage reticulation in 2006 and the Ohau Diversion Wall at Lake Rotoiti in 2008. The cost to the RDC of providing sewerage reticulation treatment was significant. The city treatment plant was also progressively upgraded to deal with increased inflows.

Central government agencies also suggested the potential to develop a series of positive relationships with community groups including, for example, the Forest Restoration Trust and a number of iwi groups just coming though Treaty settlements. These types of groups can use conservation and environmental projects that can be guided to manage land to accommodate for the impacts of climate change. Other potential levers for change identified by influencer groups included the role of the Landcare Trust work with farmers, who could become climate change champions using success stories with their peers across farming communities.

CONCLUSIONS

This research has identified information needed to enhance adaptive capacity and increase coordination to support decision making to address climate change risks in New Zealand using collaborative engagement based on the co-production of scientific knowledge through communities of practice. There was an expressed aim to increase the relevance of climate change science for decision making and to build decision-making capacity. The methodological emphasis on knowledge co-production with stakeholders helped identify those climate parameters and impacts critical for stakeholder decision-making. A mix of qualitative methods was used to understand the nature and timing of the decision-making landscapes of public, private, and influential stakeholders.

The insights generated through this research have delivered new knowledge about the potential impacts of climate change in New Zealand. The research has also obtained insights into the decision-making processes across public and private sectors and key influencers involved in addressing those risks. These findings will increase foresight through greater awareness and understanding.

Nine principal themes emerged through an iterative analysis of the empirical material: perceptions of climate change risk, climate change information, impacts, cascades, decision making, governance and institutions, organisational capacity and capability. Barriers to decision making and critical leverage points for the uptake of decision-relevant climate and impacts information and its use in decision making where climate risk profiles are changing over time, were also identified.

Perceptions of climate change risk

For the private sector, vulnerabilities arising through natural systems were the starting point for considering climate change risks. Many saw these as dominant in their domain (global market risk) or regarded climate change issues as implicitly captured within existing risk considerations; for example, disease and pest management leading to market access issues, shareholder risk and business risk (interruption and lending), economic risk, increased energy demand, and insurance risk. This has led to largely reactive responses to extremes events, rather than anticipatory risk management or adaptive planning approaches. Exceptions included the ski and merino wool industries, which were taking a more strategic approach. For the private sector, there was a perception of high costs upfront for addressing climate-related risks, especially in the primary production and infrastructure sectors.

The public sector was largely driven by their responsibilities under statutory frameworks and liabilities' set up under them. This has driven anticipatory decision making for managing climate change risk in coastal and flood-risk situations. Public agencies also showed a greater perception of the inter-connectedness of risks; a product of their many functions.

Across all respondents, regional and district councils had a more nuanced appreciation of how risk changes with time. However, there was a disconnect when it came to translating that understanding into operations and practice on the ground, although this was starting to change in some localities (e.g., Tasman District and Greater Wellington Regional Council) where exemplars of adaptive practice were evident.

Where systems thinking has been adopted by some government operational agencies, this has enabled long-term thinking about risks, with stakeholder interests. The key factor in overcoming reactive risk management was understanding how to address uncertainty when translating risk assessments into planning measures.

Climate change information

All respondents saw the value of including climate change information when carrying out their planning activities and some called for higher resolution data. The lack of 'whole of system' or integrated research was identified as a gap by both public and private sectors. Furthermore, biodiversity conservation and biosecurity management were identified as areas where research is needed to test their sensitivity to changing climate risk profiles. There were also calls for scenarios and vulnerability information for decision making. Two physical science gaps identified were a better understanding of the interaction between sea-level rise and groundwater flooding; and the effects of salt water intrusion on ecosystems. An emerging gap identified was the most appropriate governance, policy tools, and measures that can enable retreat from the coast as sea levels rise.

There was a general call for materials to inform the public and communities about the climate risks, with a view to both including these groups in decision

making and facilitating more effective private risk management.

Experienced and anticipated impacts

The following impacts were highlighted:

- Higher mean temperatures affecting drought response, biodiversity and impacts on particular crops (kiwifruit) or diseases (forestry), and utility operating conditions (ski and electricity sectors);
- Increased frequency of high-intensity rainfall events and effects on urban storm water, ponding, integrity and affordability of protection measures, and infrastructure dependent agriculture (e.g., irrigated dairying);
- Sea-level rise and coastal inundation on urban systems function and private property; and
- Some impacts have the potential to cascade, whereby one impact leads to a chain of events affecting a system or across a number of domains.

In general, the public sector was more attuned to climate impacts than the private sector. It was notable that local government was able to clearly articulate potential climate impacts on its responsibilities, and in some cases, was in the preliminary stages of developing approaches to address them.

The private sector, in general, had yet to consider how changing climate risk profiles would impact its businesses. Notable exceptions included kiwifruit, electricity transmission and hydro-generation industries, and, to a more limited extent, forestry, transport, and merino wool sectors. Serious questions regarding the capacity of the private sector to manage changing risk profiles over time remain largely unanswered, because it is yet to consider them.

The differences between public, private, and influencer groups were largely a function of scale. A majority of national-level influencers were able to engage in detailed conversations on potential climate change impacts, although many had not yet advanced strategies to address them.

Cascades

Climate change will also create cascades of implications, resulting in a chain of events affecting multiple system domains, including governance. Rainfall extremes can disrupt productive land uses, affecting quality and yield, with implications for transport networks, port access, trade, and economic exchange. Increased irrigation and shifts in land use in response to a drier climate, may result in pastoral farmers moving stock to steeper country, increasing runoff and erosion, with downstream water quality impacts. Such cascading impacts are identified here, but to date there has been little attention to them.

Cascades are created because of the functional linkages between land and water management, energy, and climate change. However, these issues are often treated separately. In addition, inter-basin water transfers and ground water pumping, are energy intensive. Promoting them as a drought mitigation solution or to boost productivity may have implications for sustainability. Such 'nexus' issues also have social consequences. Urban and rural populations may place different values on freshwater than productive sectors, leading to growing tensions over managing this resource. Nexus issues have received only limited attention to date; the integrated tools and solutions required to guide decision making are, therefore, lacking.

Governance and institutions

Fragmentation of governance arrangements across scales and within organisations, was found to be an important issue. In particular, respondents highlighted the need for greater linkages across public agencies where decisions at one scale or function affect another. The need for greater national consistency in addressing climate change impacts across New Zealand was also consistently reported by respondents. This research provides a basis for a conceptual model for strategic thinking about the implications of climate change.

Decision making

By seeking to understand what drives decision making across public, private, and influencer groups, the ever-present decision-making challenge of managing change over long time frames, emerged as a central issue.

There were also strong dependencies between public and private sector decisions. Public sector groups are largely driven by regulatory frameworks and functional mandates.

A wide range of public decision types were identified, including operating design conditions for utilities, power lines, generation, transmission, underground services for the three waters, flood-risk management, coastal-zone management, land-use planning for urban development, and transport networks.

Risk aversion and single-purpose policy decision making were characteristic across central and local government and often driven by climate events. Episodic extreme climate events motivate both public and private sectors, but in different ways. Private sector and public sector service delivery agencies are driven largely by economic incentives and investment cycles, including land prices and short time frames. Many of the other private sector players had not developed strategies for how climate change might affect their current business operations. However there was generally less inertia in the private sector to climate events; adapting quickly but usually incrementally, rather an in an anticipatory manner. Influencer groups were driven by public or private interests, and, in coastal areas, often by both. While the public sector generally has a longer-term focus than the private sector, in practice there was a mixed public sector response.

There was little evidence of infrastructure investment decisions that persist over time being linked to their ability to adapt to climate changes over longer time frames. An exception was for electricity transmission, which had a procedure in place to do so.

Liability was understood in terms of being liable for getting the information wrong, rather than liability for not implementing statutory responsibilities. A significant tension was reported between the statutory requirements and pressures on decision makers in a short-term electoral cycle to satisfy short-term private interests, and consideration of the consequences of risk transfer between generations.

Resilience gained a higher public profile during the course of this research, as a framing for risk management. This was, however framed as 'bouncing back to the status quo' which misses the opportunity to plan for the long term by adjusting or redesigning in an adaptive manner following climate 'events'. It was noted by some local government respondents that areas augmented by irrigation were the same ones where the water shortages were likely to increase due to climate change. Infrastructure investments in that case, could be maladapted to a changing climate, leading to greater exposure in the farming and urban sectors to climate risks, with consequent and cascading financial and social impacts for both current and future generations. Adaptation is actioned as a contingent risk, rather than anticipation of consequences that can be addressed ahead of damage.

Organisational capacity and capability

The organisational capability and capacity to manage climate change impacts and implications through management processes, self-efficacy, and resource mobilisation were seen as critical to addressing the risks from climate change. In general, local government and large businesses have more formal to semi-formal risk management processes in place. With the exception of local government, few considered climate change risk directly. Most risk management processes and practices were linked to other specific issues; for example, fire risk – not climate change.

Urban areas were highlighted as particular areas of concern, due to anticipated challenges of managing the human and technical dimensions of adjustments that go beyond incremental changes, especially as sea levels rise.

The fragmented manner in which climate risks are managed in most organisations was notable. There emerged a high degree of confidence in the ability to act upon risks already confronted, based on past experience. There was lower confidence in managing future risks for which they lacked information on impacts; for example, in urban areas where capacity will need to scale up.

Organisational capability falls along a spectrum, depending on size, focus, and degree of integration of functions within agencies, and across governance levels. Capability is variable across a range of climate change impacts, and is hampered by diminishing access to knowledge and information. This diminishing access can be due to organisational restructurings and staff turn-over. Other issues include low priority of climate change compared to other more immediate risks, and a lack of some key skills (e.g., hydrology and systems thinkers), reliance on external consultants, a lack of continuity, and a lack of capability to translate understanding of impacts into practical solutions. Capability was also affected by out-of-date or inadequate coverage of some data, e.g., LiDAR for coastal hazard risk and sea-level rise impacts.

Barriers to decision making

Five kinds of barriers influencing decision making emerged – governance, policy, uncertainty, resources, and psychosocial factors. Governance and psychosocial barriers created the largest impediments to effective decision-making relating to climate change impacts and implications. The most frequently cited governance barrier is a mismatch between the time horizons for

adaptation decisions and political and management practices.

Respondents described considerable scepticism in the public and amongst some elected representatives that often hampers long-term thinking about climate change. A need was identified for greater understanding of how decisions could be made under uncertain conditions without definitive numbers and proof of cause-and-effect relationships.

Critical leverage points

Focus on consequences and implementation issues emerged as critical leverage points for shifting practice towards long-term physical, social, and fiscal risks, and recognising the limits to 'protection'. The sharing of knowledge and practice examples that exemplify conceptual frameworks that enable planning for climate change impacts and their implications over long time frames and that account for changing climate risk profiles was seen as crucial. The importance of socially-constructed understanding emerged as crucial for embedding robust planning approaches that retain flexibility to change course in the future, whatever climate outcomes emerge.

NEXT STEPS AND RECOMMENDATIONS

There are productive initiatives identified in this report that are developing across many sectors, building capacity to respond to climate change impacts and their implications. This is despite the barriers identified by respondents in this research. The biggest challenge going forward, however, is the risk that these largely ad hoc and unconnected responses may work against each other, leading to maladaptation that results in large adjustment costs in the future. Furthermore, there is a growing awareness of the significance of climate change impacts for New Zealand and the key risks have been identified (Reisinger et al., 2014; Royal Society of New Zealand, 2016). The Deep South Science Challenge (DSC) has identified sea-level rise, extreme weather events, drought, and shifts in temperature, and rainfall and wind statistics, as areas for impacts research focus; for the DSC implications focus, local government (urban systems), infrastructure, and financial domains have been identified. These priorities match well with the findings of this research regarding the scope of impacts. The potential for compounding and cascading impacts with wide structural, social, and economic implications have been identified in this report, but are not yet fully understood in the New Zealand context. The DSC has recently funded further research on cascading impacts.

However, other priority implications of climate change identified in this report, such as for pest management and biodiversity management, are also likely to be affected by cascading impacts and are not currently the focus of research. These will have significant public policy implications that could be addressed by the Biological Heritage Science Challenge in the context of implementing 'Predator Free New Zealand'; basing such a programme on current climate assumptions will not adequately address the changing risks that climate change bring.

RECOMMENDATION

1) That the Biological Heritage National Science Challenge consider the effect of climate change on the management of pests and diseases that will inevitably affect the integrity of our natural biological heritage; and

2) That central government consider the effect of climate change on the veracity of its "Predator Free New Zealand" initiative in light of the impacts of a changing-climate risk profile and the implications for cost-effective pest management.

Our research has identified inadequacies within the current institutional frameworks and practice. There are misaligned and fragmented elements that are leading to decision frameworks that are inconsistent, inefficient, and have the potential to counteract each other. There are two components to this inadequacy. First, time frames for action are misaligned, e.g., a short-term political cycle drives a focus on static and disaster responses that are inadequate for the needs of long-term adaptive planning that could create space for changing course in the future without large disruption costs. Second, frameworks were not designed with changing risk as a driver of institutional design. More adequate institutional frameworks and measures for adaptation could motivate a more efficient adaptation response.

RECOMMENDATION

3) That central and local government address the institutional 'fit' of the current frameworks and measures available to adequately motivate adaptation to climate change impacts in an efficient manner.

Leveraging change that integrates climate change impacts and implications into decision making requires governance and institutional enablers to be in place to support decision making and its implementation by all sectors. Our research identified better integration and alignment of the statutory frameworks as urgent and necessary to motivate adaptation action. In addition, specific institutional measures will be required; for example, to fund adaptation where existing enablers are insufficient, for adequate anticipation of the consequences, and for implementation of adaptation measures. Opportunities to motivate adaptation need to be identified and acted upon. This will require careful analysis of the design features of institutions that are able to respond to changing climate-risk profiles; either building on current institutions, or designing new ones that can support the democratic processes of decision makers mandated to respond to climate change impacts.

RECOMMENDATION

4) That central and local government address the need for new institutions and measures, that can respond to changing climate risk profiles occurring concurrently around New Zealand, and that will compound in some

areas; for example, funding measures, analytical tools for costing the future, and measures that can address short-term and long-term decisions that do not create path dependency and future disruptive costs.

This brings us to the nature of scientific enquiry in building knowledge about climate change impacts and implications. We started the enquiry by seeking to understand the nature of the decision processes. These were entry points for addressing climate change impacts in different domains, and the likely implications of climate change for their respective sectors. Our research, thus, sought to understand the decision drivers, and the values and cultures that form them. This quickly gave us insights into the level and type of information needed (fit for purpose) and how the information was used. It also gave us insights into current levels of climate change risk understanding, information needs, and sector implications. We also learned that several sectors were adapting to climate change, or rather, devising processes to enable decisions to be made adaptively over time.

The approach taken was significantly different from the traditional pipeline approach to knowledge generation, which typically ends once the information is produced. Our approach, by contrast, enabled iteration with end users to produce relevant knowledge and to identify gaps in our current understanding. This approach of 'embedding' end users in research processes, or conversely being embedded in real-life decision processes, is a crucial shift in the nature of research in New Zealand. It offers the promise of building capacity for climate change adaptation, where actions need to be enabled and incentivised within the decision-making community that is largely independent of the scientific community. This research also provides a set of experiences and capacities that can be built on for further collaborative co-generated research on climate change impacts and implications that can enable New Zealanders to adapt and manage the risks of climate change.

Collaborative co-generation of climate change knowledge is in its infancy in New Zealand. It brought with it challenges in this research programme, including the ability to integrate different programmatic paradigms that underpin the different disciplines involved. Results reported here show promise for research conducted from a user and decision-maker perspective.

To build on this research, more effort in designing multi-disciplinary and integrated research programmes will be required through building the capacity base of researchers by 'learning by doing' and evaluating the progress made. MBIE plays a key role in ensuring that the evaluation of research processes is an integral part of research programme design.

RECOMMENDATION

5) That funders of research invest in science capability and capacity to conduct multi-disciplinary research programmes that address the climate change challenges, to ensure that the problems that climate change present to New Zealand can be responded to adequately.

6) That funders of research ensure that progress in integrated multi-disciplinary research is evaluated routinely for lessons that can build capacity.

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APPENDIX 1
RESEARCH PARTICIPANT ORGANISATIONS

Auckland Council
Bay of Plenty Regional Council
Beef and Lamb
Blakely Pacific New Zealand
Coast and Catchment Ltd
City Forests Ltd
Christchurch City Council
Dairy NZ
Department of Conservation
Dunedin City Council
Eastern Bay of Plenty
Environment Canterbury
Environment Waikato
Federated Farmers
Fish and Game New Zealand
Fonterra
Forest and Bird Protection Society
Greater Wellington Regional Council
Hancock Forest Management
Hauraki District Council
Hikurangi Farm Forests
Horizons Manawatu
Hutt City Council
Insurance Council New Zealand
Invercargill City Council
Kapiti Coast District Council
Lakes and Water Quality Society
Lake Pukaki Wilding Trust
Landcare Trust
Local Government New Zealand
Lo Tech Aquaculture
Mackenzie District Council
Mackenzie Guardians
Maketu Wetland Trust
Meridian Energy
Mighty River Power
Ministry of Business, Innovation and Employment
Ministry of Primary Industries
Ministry for Environment
Ngati Poru Fisheries
37 Degrees South (consultancy)
New Zealand Bankers Association
New Zealand Institute of Forestry
NZ Merino
Opus Environmental Consultants
Panuku Development Auckland
Rural Women New Zealand
Seafic (Seafood Industry Council)
Tasman District Council
Tauranga City Council
Te Arawa Lakes Trust
Te Tumu Landowners Group
Thames Coromandel District Council
Tonkin and Taylor
Tourism Industry Association
Tourism New Zealand
Transpower
University of Waikato
Upper Waitaki Zone Committee
Waikato Regional Council
Wellington City Council
Western Bay District Council
Zespri

APPENDIX 2
CHARACTERISATION OF RISK AND TOOLS

Characterisation of risk

The following figures illustrate different ways of communicating changing risk profiles:

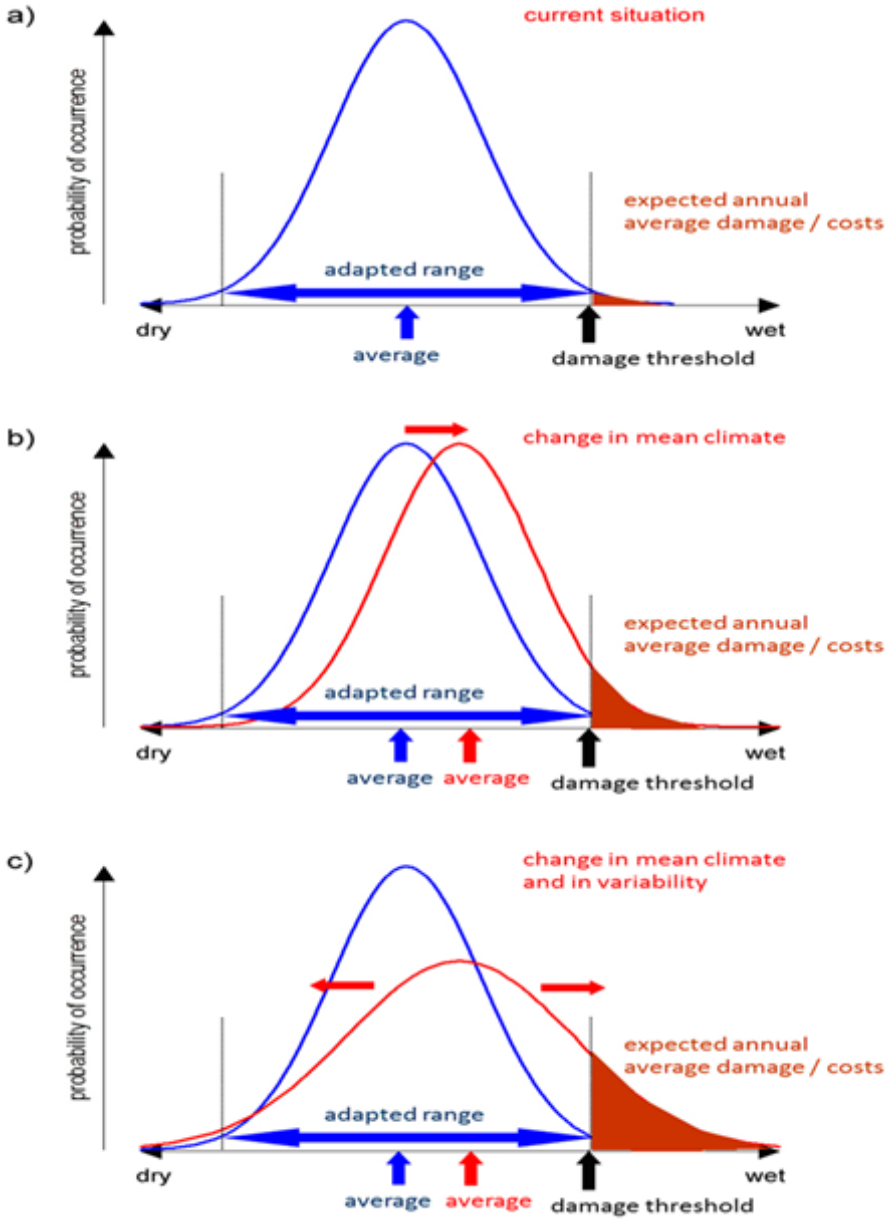


Figure 2-1: Changes in extremes with changes in mean climate.
Source: Andy Reisinger adapted from IPCC (2012) Figure SPM3.

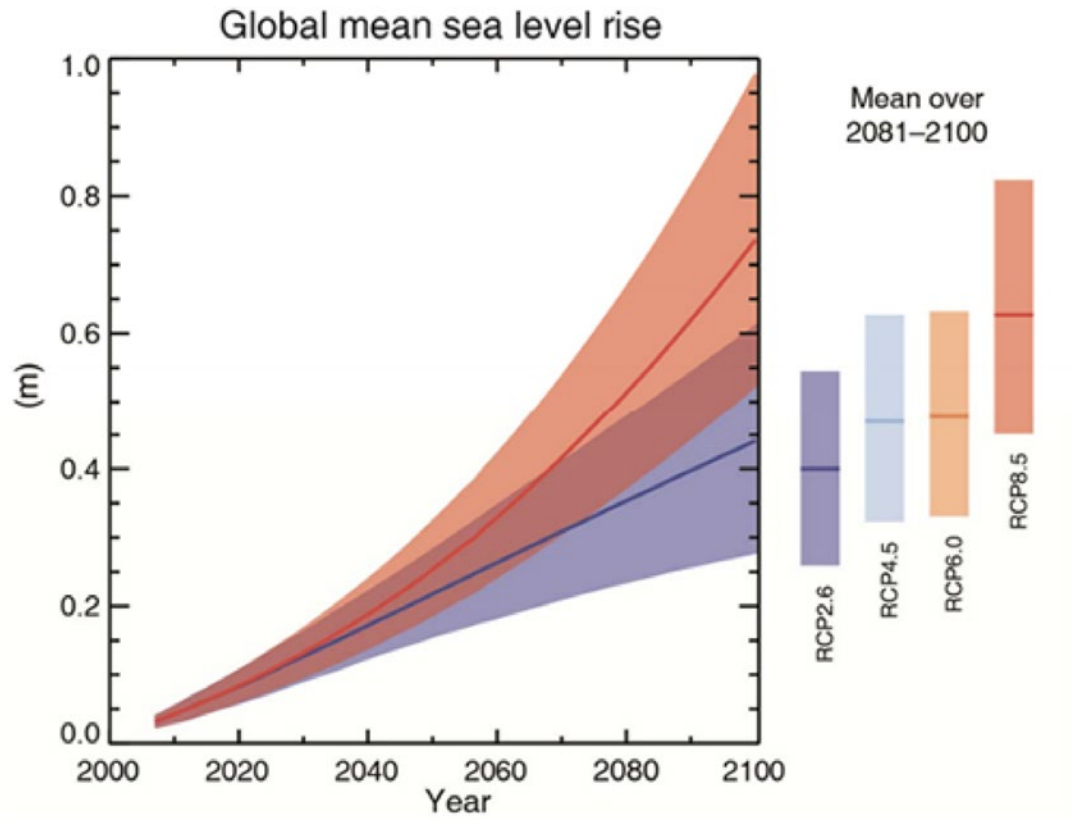


Figure 2-2: Global mean sea-level rise. Upper and lower likely ranges.

Source: IPCC, (2013, p. 24). Figure SPM.9 Projections of global mean sea level rise over the 21st Century relative to 1986–2005 from the combination of the CMIP5 ensemble with process-based models, for RCP2.6 and RCP8.5. The assessed likely range is shown as a shaded band. The assessed likely ranges for the mean over the period 2081–2100 for all RCP scenarios are given as coloured vertical bars, with the corresponding median value given as a horizontal line.

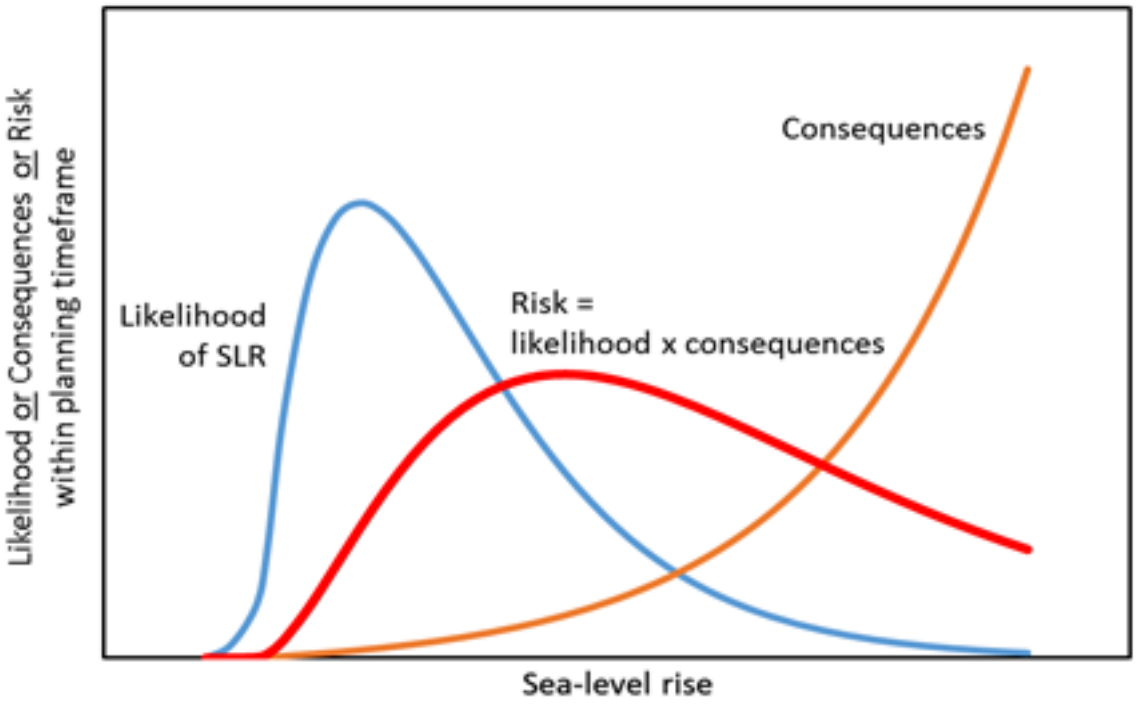


Figure 2-3: Risk=likelihood x consequences: The importance of consequences.

Tools that enable uncertainty and changing risk profiles to be addressed

a) *Dynamic Adaptive Pathways Planning (DAPP)* has emerged as a practical approach to support private and government decision-making in a changing climate with widening future uncertainties. In particular, the DAPP can be used for planning ahead for changing risk profiles and climate change uncertainty relating to sea-level rise, changing flood frequency and rainfall intensity, and drought.

The Dynamic Adaptive Pathways Planning approach (Haasnoot, Kwakkel, Walker, & ter Maat, 2013) was developed by Deltares (The Netherlands) and is an exploratory model-based planning tool that helps in the design of adaptive and robust strategies over different scenarios of the future. In the context of rising sea levels, where conflicting values prevail, the consequences of decisions on future generations and the environment may be profound and irreversible, resulting in activities that are locked-in spatially, thus, reducing the ability of decision makers to adapt to future conditions. Costly adjustments with distributional consequences within society may result.

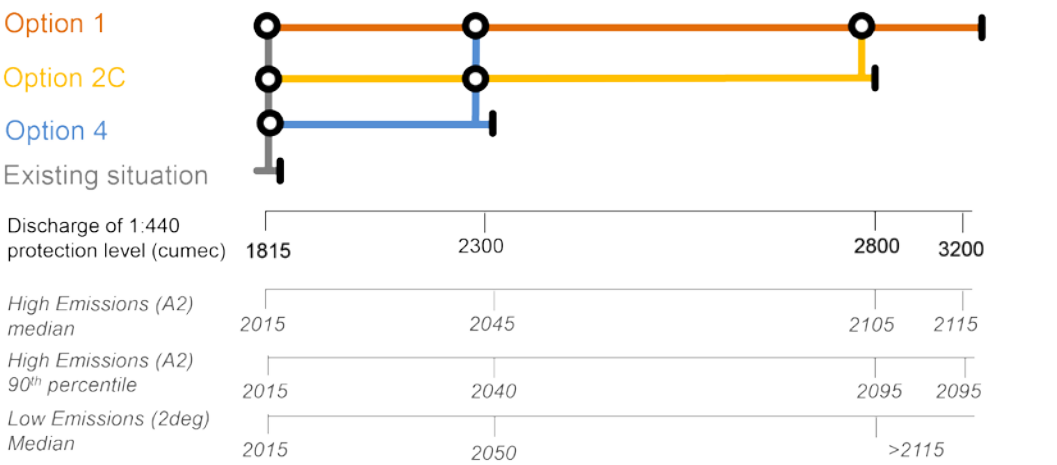
The DAPP approach starts from the premise that policies/decisions have a design life and might fail as the operating conditions change (Kwadijk et al., 2010). The DAPP focuses on keeping multiple pathway options open into the future by making transparent future actions that can be taken, when actions today prove insufficient to meet agreed objectives. To enable pathways to be implemented and managed over time, changes must be monitored. This requires signals and triggers to be developed (Haasnoot, Schellekens, Beersma, Middelkoop, & Kwadijk, 2015), enabling timely adjustments to be made. Time-dependent climate scenarios are also required to replace the 'end-point' projections commonly used. Such scenarios can be used to raise awareness about climate variability on the back of climate change and the difficulty of finding climate change attribution in climate variables, which is necessary for assessing when to adapt. Trigger points for exploring different adaptation pathways can be identified for doing this. The DAPP can be used to facilitate iterative decision making with communities where coastal hazards and sea-level rise compound and where increased frequency of storms and flood risk occur.

When using the DAPP approach to assess different policy options and measures for adaptive management, a set of questions are asked that facilitate consideration of the risk over a long time frame. The questions are used to assess different strategies that enable long- and short-term objectives to be met under different scenarios of the future. This enables their consequences to be considered in the present.

- What are the first issues that we will face as a result of climate change?
- Under what conditions will current strategies become ineffective in meeting objectives?
- When will alternative strategies be needed given that implementation has a lead time?
- What alternative decision pathways can be taken?
- How robust are these pathways over a range of future climate scenarios?
- Are we able to change path easily and with minimum disruption and cost?

The options and alternative pathways and decision points (trigger points) can be drawn using iterative processes with decision makers and communities, as input to the adaptation decision-making process. An example is shown in Figure 2-4.

Once actions fail, additional or other actions are needed to achieve objectives, and a series of pathways emerge. At predetermined trigger points the course can be changed to enable the objectives to continue to be achieved. By exploring different pathways, and considering whether actions will lock in those actions and not enable adjustments in the future, thereby creating path-dependency, an adaptive plan can be designed that includes short-term actions and long-term options. The plan is monitored for signals that indicate when the next step of a pathway should be implemented or whether reassessment of the plan is needed. The signals can be those defined by thresholds in the physical processes, and socially-defined triggers that reflect the tolerance level of the community affected by the adverse consequences of sea-level rise or coastal hazard.



Pathway	Main effects: Relative Costs	Main effects: Target effects	Side effects: Social Impacts	Side effects: Transport impacts	Side effects: Environmental impacts
1	$$$$	++	----	+++	++++
2	$$	+	---	++++	+++
3	$$$$	++	----	++++	++++
4	$	-	0	++	+
5	$$$	+	--	++++	+++
6	$$$$	++	---	+++	++++
7	$$$$$	++	----	++++	++++

Figure 2-4: Example of a pathways map. Hutt river: Intensity of flood events expected to increase, but amount of change is uncertain (Greater Wellington Regional Council, 2015).

The resulting pathways can be tested for robustness with respect to a number of assumptions and parameters; for example, different climate change scenarios, the discount rate, earlier or later decision review dates, and variations in the costs of the adaptation options and in expected losses. Robustness tests can be done on a number of complementary options; for example, structural options may become unaffordable and may need to be supported by planning and regulatory options, targeted rates, and insurance.

b) *Simulation games* can be used to experience decision making under uncertainty in 'safe' test environment. The Sustainable Delta Game (the Game Deltares on line)[11], developed for the Netherlands, simulates a decision setting in a river catchment or coastal setting that helps participants to learn about preparing an adaptive plan. The game can be used to:

- Experience the future and its uncertainties;
- Raise awareness of adaptive management;
- Raise awareness of the role of negotiation and collaboration;
- Reflect on policy decisions; and
- Discuss robust and flexible policy actions.

This Game has been tailored for three different New Zealand river settings (an east and west coast South Island river and a North Island river) and for coastal settings. Details regarding the game are available at https://publicwiki.deltares.nl/pages/viewpage.action?title=Game+Materials&spaceKey=AP Access to the login can be sought from Judy Lawrence at the NZ Climate Change Research Institute at Victoria University of Wellington judy.lawrence@vuw.ac.nz

In the game, groups of participants in several teams develop a sustainable management plan for a river or coastal area by setting a vision, choosing policy actions, negotiating these policy actions with other teams, and having them simulated at several time points over a 100-year period. As the future unfolds, the participants experience what happens in the river and its catchment or the coastal area. With simulations based on environmental models (Haasnoot, Middelkoop, Van Beek, & Van Deursen, 2011) and transient scenarios (Haasnoot et al., 2015), participants

[14]http://deltagame.deltares.nl

get direct feedback on their policy actions. In addition, negative impacts of floods and droughts on nature, along with support of inhabitants, and economic growth, are taken into account when deciding on responses that may be included in the adaptive water management plan. Several scripts for game sessions are available. Each script includes a climate change scenario, context, relevant newspapers, and citizen perspectives for different situations. Figure 2.5 displays an example of such a script: transient sea-level rise scenarios, newspapers and the different time periods that are played in each round.

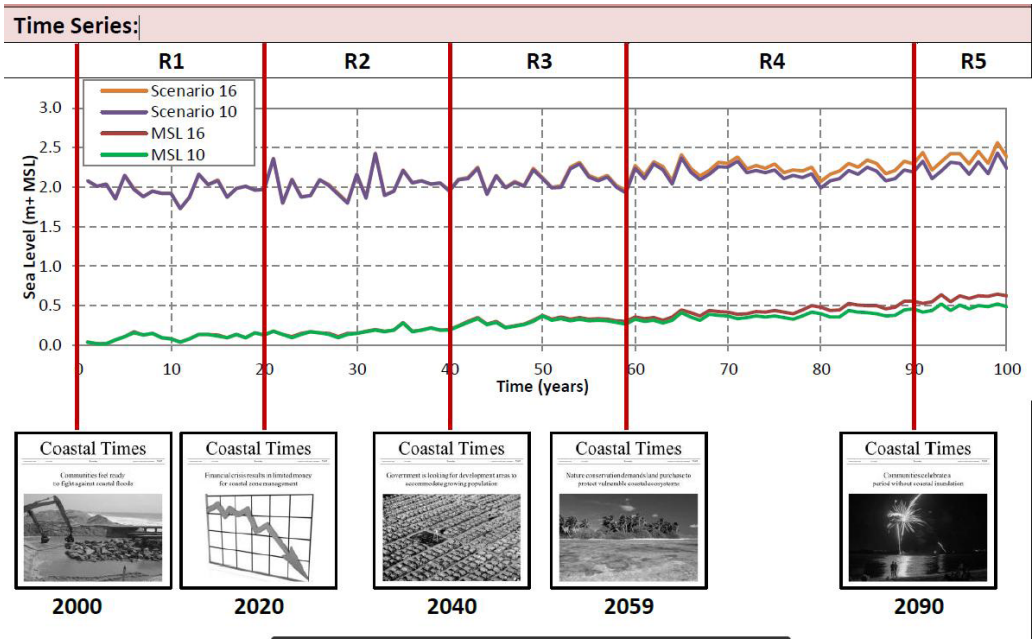


Figure 2.5: Part of a script for a game session, showing two SLR transient scenarios, the game rounds time slices, and newspapers. [Source: Sustainable Delta: NZ Coastal World Guide Tainui, Deltares 6 April 2016 https://publicwiki.deltares.nl/pages/viewpage.action?title=Game+Materials&spaceKey=AP

The simulation model (Haasnoot et al., 2012) is implemented in PCRaster (Van Deursen, 1995). It describes the cause-effect relationships within the water system based on results of more complex hydrological and impact modelling previously applied on the Rhine-Meuse Delta. The model was checked for internal consistency and for plausibility of the outcomes by expert judgment. The effects of different transient climate change scenarios (Haasnoot et al., 2015) are considered through changes in river discharge that cover typically flood and drought situations.

For the New Zealand version of the game, the river inflows were scaled because local rivers are much smaller relative to the Rhine River. The model then calculates the effects of flood events on river water levels, probability of levee failure, flood damage, and impacts on agriculture and biodiversity

After the simulation game, the participants and facilitator reflect on what happened during the simulation as the storyline developed, and on the adaptation pathway that emerged. They discuss what triggered this pathway, how it can be improved, and what it could mean in practice using the following questions:

- Were there actions that were more effective than others?
- Did you behave in a more reactive or proactive way?
- At what point in the game did you experience a change in strategy?
- What arguments did you use to change the strategy?

- What uncertainties did you experience?
- What was the role of the negotiation with the other teams?
- In hindsight, would you have played the game differently?
- What did you learn from the game session?
- Other comments?

In this context, different possible futures are considered and the path-dependency, robustness, and adaptive capacity of actions are discussed. The game primarily has learning objectives, but it can change behaviour, which then influences how adaptive pathways are subsequently developed. It can be used by technical advisors, elected politicians (decision makers), and in community engagement settings. By using this approach, the game supports a number of objectives helping participants to:

- Learn about water and coastal system processes;
- Learn about adaptive policy making, adaptation tipping points, and adaptation pathways;
- Experience a decision-making process within a changing environment full of uncertainty;
- Discuss the use of scenarios for planning and sustainable water and coastal management; and
- Discuss and develop innovative solutions for addressing changing risk profiles.