REPORT

Tonkin+Taylor

Canterbury Climate Change Risk Screening

Interim Report

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Table of contents

DRAFT

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Executive Summary

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Tonkin + Taylor (T+T) and Environment Canterbury recently carried out a Climate Change Risk Screening assessment for Canterbury. This project aimed to understand the existing and future climate change risks and opportunities for Canterbury.

This project was undertaken at the end of 2019 to allow the opportunity for the results of this assessment to feed into the National Climate Change Risk Assessment (NCCRA), which helps to improve our understanding of the climate change risks and opportunities that New Zealand faces.

This project provided a broad overview of climate risk, based on the risks and opportunities identified through an elicitation process. This should be followed by a risk assessment that goes into more detail on the priority risks and opportunities identified through this process.

How we did it

We held workshops and meetings with Environment Canterbury, Canterbury councils, and Te Rūnanga o Ngāi Tahu representatives as treaty partners. We also had experts from Landcare and NIWA add their knowledge. During these meetings, we looked at five "value domains": the built environment, economy, natural environment, human domain, and governance. During each workshop we recorded the risks from climate change identified by the workshop participants, as well as a list of opportunities

Summary of results

The result of these meetings was a list of risks that are predicted to have the greatest effect across the Canterbury region. These risks were measured based on the climate hazards that affect them, and the impact that the risk is likely to have on the region. For the risks in the built environment, natural environment, and economy value domains, over 180 risks were identified. Of these, 55% were assessed as moderate, major or extreme risks. Within those three value domains, 46% of risks were identified as priority risks, having a big impact on the region. Some direct risks within each value domain are listed below, and discussed in more detail in the main report.

Māori perspective

We worked with Te Rūnanga o Ngāi Tahu climate change representatives and identified through workshopping that the existing value domains were not necessarily the best way of assessing climate risks within Te Āo Māori and Mātauranga Māori. This is because the value domain format assesses each risk independently (i.e. in absolute), but when these values are looked at through a Mātauranga Māori frame, they are inherently interlinked.

Te Rūnanga o Ngāi Tahu representatives worked with our team to evolve the Whare Tapa Wha model (originally developed from the health sector), which identifies the four pillars of life (hinengaro (psychological), wairua (spiritual), tinana (physical), and whanau (family)). To this existing model, the concepts of Rangatiratanga (governance), Kaitiakitanga (guardianship), Whakapapa (genealogy), Taiao (environment) and the economy were added. We collectively agreed that this Whare Tapa Wha approach should be strongly considered in any future assessments.

Built environment domain risks

Climate hazards most likely to present risk to the built environment include sea level rise, flooding, coastal erosion, fire, higher temperatures, drought, storms, landslides, and reduced snow and ice. These hazards are likely to affect urban communities, rural communities, flood management schemes and stopbanks, water supply infrastructure, irrigation and water races, wastewater treatment plants, roads and bridges, rail, marine facilities, airports, solid waste and contaminated sites, and coastal barriers and seawalls.

Economy domain risks
Climate hazards that might affect the economy domain include flooding, fire, higher temperatures, drought, storms and wind, reduced snow and ice, marine heatwaves, and changes in ocean chemistry. These hazards will likely affect livestock, crops, forestry, fishing and aquaculture, and tourism.

Natural environment domain risks
Key climate hazards in the natural environment domain include sea level rise, flooding, coastal erosion, fire, higher air temperature, drought, storms and wind, annual rainfall changes, reduced snow and ice, marine heatwaves, and changes in ocean chemistry. These hazards are likely to affect native terrestrial, freshwater, and marine biodiversity; ground and surface water availability and quality; water quality in marine, estuaries, harbours, lakes, and rivers; natural coastal habitats (such as dunes, estuaries, and rocky shores); coastal wetlands; lowland and coastal environments; mountain and hill country environments; alpine and high country environments; and terrestrial, freshwater, and marine pests and disease.

Human domain risks
We used a slightly different methodology to measure this domain because of the challenge of measuring the indirect effects that different climate hazards could have on people and communities.

Some of the biggest risks that climate hazards could cause in the human domain include direct and indirect impacts on health, impacts on mental health and wellbeing, impacts on community cohesion and stability, a reduction in community capacity and resilience, impacts on Maori, and impacts on the capability of government agencies.

Governance domain risks
Climate change will present significant challenges and risks for governance, including impacts on emergency planning and response as well as recovery operations; the ability to fund and maintain infrastructure and public services; the functioning of planning rules and policies; insurance and banking systems; the functioning of social service agencies; legal liability; water governance; and reputation of institutions.

Opportunities across the five domains

Canterbury may experience a few opportunities in the built environment, directly from physical climate change, and from responses to a changing climate. These include the opportunity for more renewable energy due to increased sunshine hours, and the potential for wastewater ponds to operate more efficiently in warmer temperatures.

Economic benefits in Canterbury due to climate change may include growth in agriculture (as a result of changing seasonal climate patterns), and increases in tourism (resulting from an increased summer season). For the Natural environment, opportunities identified within the workshop included opportunities for better land use and potential for ecosystem-based adaptation to climate change.

Opportunities under the human domain could include improved health and wellbeing as a result of warmer temperatures. Finally, opportunities for governance through climate change are limited, but these may include more empowered communities and possible access to new funding sources.

Next steps

This assessment produced an overview of possible climate change risks. Next, we recommend a more detailed risk assessment and more research on specific elements at risk. This will give us an improved understanding of climate risks, and will help us to create a region that is more prepared for climate change.

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1 Introduction

Environment Canterbury commissioned Tonkin & Taylor Ltd (T+T) to carry out the first climate change risk screening for Canterbury. We recognise the importance of the Canterbury Climate Change Risk Screening (CCCRS), both for the region and Aotearoa New Zealand. It will provide better information about existing and future climate change risks, and allow the region to contribute to the National Climate Change Risk Assessment (NCCRA). This risk screening is the first part of a more detailed risk assessment yet to be commissioned.

Under the NCCRA, a climate risk assessment includes:

1 High-level risk screening to identify priority risks;

2 Detailed risk assessment for priority risks;

3 Adaptation plan.

The objectives, and therefore deliverables of this project, include:

a Establish understanding of elements at risk in Canterbury;

b Rank elements at risk based on their consequences on each of the value domains;

c Provide a prioritised list of elements at risk, including documenting adaptations (where possible);

d Establish transition risks relevant for Canterbury;

e Understand opportunities associated with physical and transition risks for Canterbury.

2 Understanding climate change

It is internationally accepted that the climate is changing due to increasing quantities of greenhouse gases in the atmosphere. These changes have been observed at a global and regional level, with warming agreed as unequivocal. Climate change poses an unprecedented level of risk to Aotearoa New Zealand, involving rising sea levels as well as changes in rainfall and temperature patterns (MfE, 2017).

Climate change and associated risks vary over time, so risk assessments should consider a range of time horizons where possible. Projections for climate change variables and associated risks become more uncertain over longer time horizons, given the variations associated with longer extrapolations.

Climate model simulations have been published by the Intergovernmental Panel on Climate Change (IPCC) and help provide an understanding of climate change. Four scenarios, known as representative concentration pathways (RCPs), provide projected temperature changes based on a range of greenhouse gas concentrations in the atmosphere. These global climate models have been downscaled for New Zealand by the Ministry for the Environment (MfE, 2017).

This screening exercise focused on only RCP8.5, known as the *reasonable worst case* scenario, to make sure that all reasonable risk elements were captured. Present-day and long-term (2090s) timeframes were also considered, as described further below.

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3 Information review

The CCCRS follows the NCCRA Framework's guiding principles. A risk screening is Stage 1 of the NCCRA Framework's detailed methodology. This section provides an overview of the various steps involved in this first stage.

At the outset, Environment Canterbury provided information including:

- A literature review summarising relevant research;
- A climate change hazards list for Canterbury;
- Some pre-identified transition risks for Canterbury;
- Stakeholder and Treaty Partner lists.

Given the broad nature of this first CCCRS, this information provided the basis for a 'long list' of climate risks for Canterbury. This long list was validated and reviewed in workshops held with Canterbury's regional and territorial councils. More information about the long list process is provided below.

Please note that the taxonomy (the way things are classified and named) in climate change risk assessment is complex, with a multitude of conceptual models and sets of terms, parameters and definitions. The taxonomy in this report follows that of the NCCRA Framework and the IPCC (2014) Report; key terms are listed and defined in Appendix B.

3.1 Gap analysis and information assessment

As a first step, the Canterbury hazards list (Environment Canterbury, 2019) and the literature review (Landcare, 2019), were assessed.

3.1.1 Hazard list

The Canterbury hazards list includes a number of climate hazards that have already been identified. It is predominantly based on the example list provided within the NCCRA Framework, and includes changes in temperature (air and water), precipitation, seasonal variations, ocean acidification and extreme weather events. The Canterbury hazards list includes projected changes for the hazards (magnitude and direction) currently (present day) along with two future timeframes, mid and long term (2040s and 2090s respectively) for RCP8.5 emissions scenario. This information was based on the national climate change projections report (MfE, 2017).

Climate projections have inherent levels of uncertainty, which increase with the timeframes – long term projections are generally more uncertain than mid term. There is also uncertainty due to potential regional variability of hazards (for example, the extent of coastal erosion along the Canterbury coastline may vary at different locations).

3.1.2 Literature review

Environment Canterbury commissioned Manaaki Whenua - Landcare Research to do a literature review of climate impacts facing the region (Landcare, 2019). The literature review covers projected climate driven hazards, opportunities and risks from transitioning to a low-emissions future, and a number of indirect cascading impacts expected across value domains. The literature review was the primary source for understanding potential climate change impacts for Canterbury.

While the literature review provided details on the impact of hazards on key elements and sectors, there are gaps. For example, the impact on livestock farming is provided (both for dairy and sheep/pasture), but the impact on different forms of forestry is not included (for example, sensitivity of both exotic and native species). Similarly, there were gaps around other economic sectors, and

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natural environment sectors. In addition, the literature review does not include details of existing and planned adaptation actions across the five value domains.

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4 Risk screening framework

The conceptual framework used for this risk screening follows the guiding principles of the NCCRA Framework for defining and determining climate risk. This includes encompassing the five value domains identified within the NCCRA Framework: Human, Natural environment, Built environment, Economy, and Governance.

Environment Canterbury also included transition risks and opportunities within the scope of its risk screening process. To incorporate this wider focus, the guiding principles of the Taskforce for Climate-related Financial Disclosures (TCFD) framework have been used, as they consider physical risks as well as transition risks and opportunities. The TCFD framework is shown in Figure 4-1.

Figure 4-1: Types of risks and opportunities for consideration (based on TCFD)

4.1 Physical risks

The NCCRA Framework describes physical climate change risk using the key components of hazard, exposure and vulnerability. At the screening stage, an assessment of the **impact** (as a result of exposure and vulnerability) and **consequence** has been carried out, as shown in Figure 4-2 below.

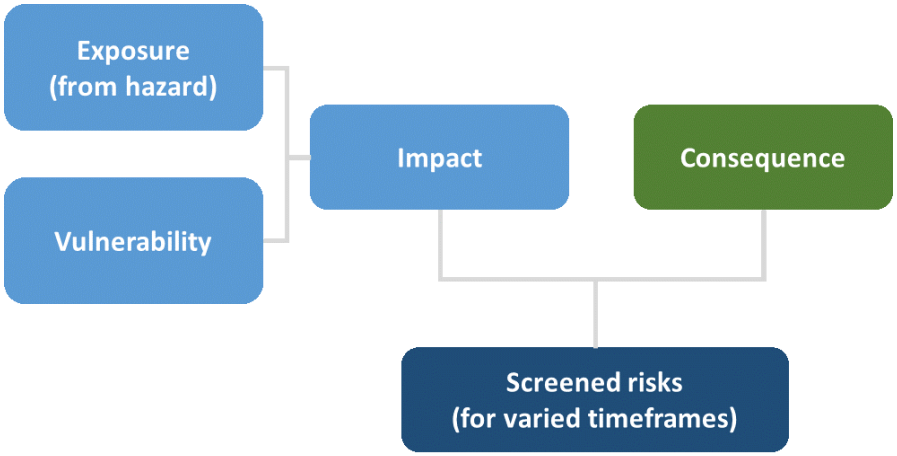

Figure 4-2: Stage 1 first-pass risk screening process (adapted from the NCCRA Framework)

4.2 Transition risks

Transition risks are defined as those that organisations face when moving to a low-carbon / climate-resilient future. These include: Policy & legal, Reputation, Governance.

As the TCFD framework was designed primarily for assessing and disclosing risk in the private sector, discussions were held with the Environment Canterbury project team to understand its application to local government and the communities that they represent.

4.3 Opportunities

Opportunities will arise from climate change, both from physical changes and transition changes (shifting to a low carbon future). Opportunities were identified and categorised within value domains. Where feasible, opportunities were captured against two timeframes.

While the consideration of opportunities is important (as it can allow Canterbury's council to better plan) the screening's main focus was establishing the highest risk areas, in line with the NCCRA Framework.

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5 Methodology

This section summarises the methodology used to establish risks and opportunities, along with detail on the workshop elicitation process. A more detailed overview is provided in Appendix A.

The CCCRS methodology looks to establish a broad understanding of climate-related risks. Risk screening is then followed by a detailed risk assessment, which both inform an adaptation assessment.

5.1 Physical risk screening

To screen for physical climate change risks, the following steps were taken:

1 Establishment, review, and validation of risk **elements** per sector and value domain;
2 Identification of existing and future climate **risks** based on RCP8.5 (long list);
3 Screening of identified risks for **impact** (as a function of exposure and vulnerability);
4 Screening of impacted risks for **consequence** (where it was possible);
5 Identification of existing and planned **adaptation actions** (where it was possible);

This involved an initial desktop study followed by a workshop elicitation process with council staff. Results of the initial risk screening were then presented to the Canterbury Climate Change Working Group (CCCWG) for review and subsequently updated.

5.2 Identifying and documenting existing and future opportunities

While the CCCRS focuses heavily on risk identification, it is important to recognise that there will likely be opportunities for Canterbury's economy, society, and environment as a result of the impacts of climate change. During each workshop, possible opportunities were identified associated with the physical impacts of climate change and transition changes with moving to a low-carbon climate resilient economy. The specific physical climate change hazards giving rise to an opportunity have been identified where applicable (for example, changes in seasonality give rise to a longer growing season).

5.3 Transition risks

The list of transition risks provided by Environment Canterbury was reviewed, validated and challenged by participants at both full-day workshops. Any additional transition risks and opportunities identified were documented, with commentary. The resulting list was reviewed by the CCCWG, with results provided below.

5.4 Assumptions and limitations

This broad screening provides an initial stocktake of the climate change risks over two timeframes, so future work can be structured and prioritised. Its broad nature requires various assumptions to be made and has limitations, but many of these can interrogated in subsequent work. The fundamental limitation of this approach is the lack of detail. While there is a drive to understand the climate change impacts at a highly-local level, that level of detail will only emerge later in the risk assessment process - for example, through a specific spatial analysis of prioritised regional risks.

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5.5 The elicitation process

The following workshops and meetings were held for the risk screening:

- A full-day workshop in Christchurch on 7 October
- A full-day workshop in Timaru on 10 October
- A half-day meeting with Te Rūnanga o Ngāi Tahu on 18 October
- A half-day meeting with CCCWG on 18 October.

Representatives from Environment CanterburyEnvironment Canterbury, Canterbury's district councils, and Te Rūnanga o Ngāi Tahu attended various workshops and meetings. The attending council stakeholders had expertise and responsibilities relating to the five value domain areas.

The list of council stakeholders which attended are as follows:

- Built Environment: Council asset engineers, lifelines liaisons, CDEM, and land drainage;
- Natural Environment: Council planners, ecologists, contaminated land;
- Human (Society + culture): Council community planners/liaisons, education, and health;
- Economy: Council economists, business analysts, fisheries/agricultural and tourism officials;
- Governance: Council CDEM, business analysts, and defence officials.

5.5.1 Full-day council workshops

Attendance at the full day-workshops was dominated by council staff, both at local and regional levels, with over 60 staff attending. Council staff were supplemented by participants from Landcare and NIWA. These workshops focussed on the validation of risk elements, identifying key hazards to establish elements at risk, and then provide a screening of impact and consequence.

5.5.2 Meeting with Te Rūnanga o Ngāi Tahu

A meeting was held with Treaty Partners Te Rūnanga o Ngāi Tahu in Christchurch on the morning of the 18 October 2019. The aim of this meeting was to ensure that iwi knowledge (mātauranga ā iwi) and histories (hītori) were integrated into the climate risk screening. During this meeting, the framing of climate risk screening was discussed at length, understanding how differing world views could be addressed within the overall risk screening approach. This is detailed in section 6 below.

5.5.3 Meeting with the CCCWG

The meeting held with CCCWG allowed for ranked elements at risk to be reviewed, validated and challenged. This provided further reflection, reengaging some of the initial workshop attendees. Following this review, comments were noted to inform the project team review of prioritised risks ahead of aggregation, to provide a short-list of risks, presented by value domain below.

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6 Te Rūnanga o Ngāi Tahu and Climate Change

The Treaty of Waitangi establishes the platform for a partnership approach between iwi/hapū and the Crown. This partnership approach is essential in enabling decision-making on climate change interventions and adaptation – and to ensure equity of outcomes across all domains. In addition, iwi/hapū are the repositories of Mātauranga Māori, traditional knowledge gathered and passed down relating to the natural environment. Including the people who hold Mātauranga Māori to identify cultural and social differences is important as Environment CanterburyENVIRONMENT CANTERBURY begins to understand the wider climate implications on its interests, assets and populations.

The first-pass risk screening process involved one meeting with Te Rūnanga o Ngāi Tahu in Christchurch to discuss risks and capture discussions. Representatives across the spectrum of Ngāi Tahu attended. It was noted at the meeting that representation across all of the Papatipu Rūnanga within the Canterbury Region were not present, and seeking a local-based understanding of local risks would be important moving forward.

Ngāi Tahu has an established climate change strategy, which was adopted in August 2018 after substantial information collection involving research, surveys and hui. The strategy is entitled He Rautaki Mō Te Huringa o Te Āhuarangi - Te Tāhū o Te Whāriki (Te Rūnanga o Ngāi Tahu Climate Strategy - Anchoring the Foundation) and provides direction across the spectrum of Ngāi Tahu interests, assets and activities with both a traditional and contemporary lens. The strategy is aligned to the nine pou and heke of Ngāi Tahu 2025, a wide-ranging strategy for future tribal development, with corresponding long and short-term priorities. The founding interwoven principles of the Strategy are as follows:

- SHELTER: Inherent in the pou and heke structure of Ngāi Tahu 2025 – building and strengthening enduring systems to protect and care for what is important to us all;
- WEAVING: Acknowledging the interconnectedness of the various strands and aspects of the Strategy; and
- SUPPORT: As the root systems of the kahikatea, intertwine to give greater stability and resilience.

6.1 Methodology

Aligned to the process identified in section 5 of this report, a long list of climate risks was formulated based on a literature review of Mātauranga Māori and Ngāi Tahu specific literature, hazard lists and previous project experience. These were presented at the meeting, and attendees had an opportunity to discuss each risk for screening over time.

During this process, it became apparent that there was a challenge in applying a ranking mechanism for identifying consequence scores and prioritisation of risk within Mātauranga Māori. More specifically, attendees expressed a concern over the value domains adopted by the NCCRA framework, and particularly the need to assess these independently when, within a Mātauranga Māori frame applied, they are interlinked.

This discussion led to conceptualising an evolved model for considering impact and consequence – proposed as the Whare Tapa Wha model, discussed in section 6.3 below. Therefore, while a first-pass screening was not fully achieved, the risks were discussed and built upon, and an alternative model considered. The following sections provide an overview of this work.

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6.2 Mātauranga Māori and Māori values

Ngāi Tahu raised the importance of framing an understanding of climate change within Mātauranga Māori / Māori values. Mātauranga Māori encompasses all aspects of knowledge, including philosophy, beliefs, language, methods, technology and practice (Harmsworth and Awatere 2014). While mātauranga (knowledge) can be widely held, Mātauranga Māori is often held at a local level, and can be sacred to an iwi, hapū and whānau. Such knowledge can be gifted or shared, and must be treated with the same level of respect by those who receive it. Mātauranga Māori has also evolved from being not only wisdom of the past, but also of contemporary forms (new innovative approaches using traditional knowledge) representing the dynamic and evolving culture within Te Āo Māori (the Māori world).

The traditional belief systems upon which Mātauranga Māori is built is how Māori make sense of the world. This can govern the responsibilities and relationships Māori have with the environment and the way decisions are made. Important concepts when considering climate change include (but are not limited to):

- Whakapapa – connection, lineage, or genealogy between humans and ecosystems and all flora and fauna. Whakapapa is an understanding of a whole environment or ecosystem;
- Kaitiakitanga – stewardship or guardianship of the environment, an active rather than passive responsibility;
- Mana – authority or control over the management of resources;
- Ki uta ki tai – a whole-of-landscape approach, understanding and managing interconnected resources and ecosystems from the mountains to the sea;
- Tāonga tuku iho – intergenerational protection of highly valued tāonga, passed on from one generation to the next, in a caring and respectful manner. These can define what is valued, and may evolve over time.

Discussions at the meeting with Ngāi Tahu highlighted the concern that Mātauranga Māori is not often understood as equal to western science, nor represented in conversations in the same way. This tension means that there is complexity in understanding climate change matters at the mātauranga-science interface. It also may present opportunities to achieve He Hononga (an integrated approach) moving forward.

6.3 Whare Tapa Wha Concept

Due to the challenge of applying the domains to categorizing risks, attendees proposed a variation of the widely applied Whare Tapa Wha (literally translated as the house with four pillars). The Whare Tapa Wha model was first presented at a Māori Women's Welfare League hui in 1982. This was followed by a paper entitled A Māori perspective of health (Durie, 1985), which outlined differences in perspectives towards health by western society and Māori. The model presented the basic principles of life as four pillars of well-being across the spheres of:

- Taha Tinana: the physical pillar
- Taha Hinengaro: the mental, emotional and social pillar
- Taha Wairua: the spiritual pillar
- Taha Whānau : the communities, relationships and family pillar

The concept of the Whare Tapa Wha is that the house would not be able to stand without the four pillars/walls/sides, and so they are integral to the support and ongoing well-being of the house and the people within it.

While the discussion was preliminary in nature, attendees saw the value in conceptualising climate change risks and opportunities within Mātauranga Māori / from a Māori viewpoint through this

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holistic and integrated approach. A number of variations to the model described above were proposed as follows:

- Rangatiratanga and Kaitiakitanga: Governance and guardianship added as the roof structure. These demonstrate a commitment to Te Tiriti o Waitangi responsibilities and partnership agreements, and Ngāi Tahu sovereignty;
- Whakapapa: Genealogy is added as a central pillar or pou tokomanawa. Demonstrating that everything is connected, and that actions can have wide consequences. For example, if an action is undertaken by Au (self) then this can impact whanau (family), maunga (mountains) and so on;
- Whenua: Environment added as the foundations of the house. Demonstrating the importance of the environment to whakapapa (genealogy) and its connection from Ranginui (sky father) through to Papatuanuku (earth mother); and
- Economy: Added to the foundations of the house, recognising the economic sustenance required to provide ongoing support to the functioning of the house.

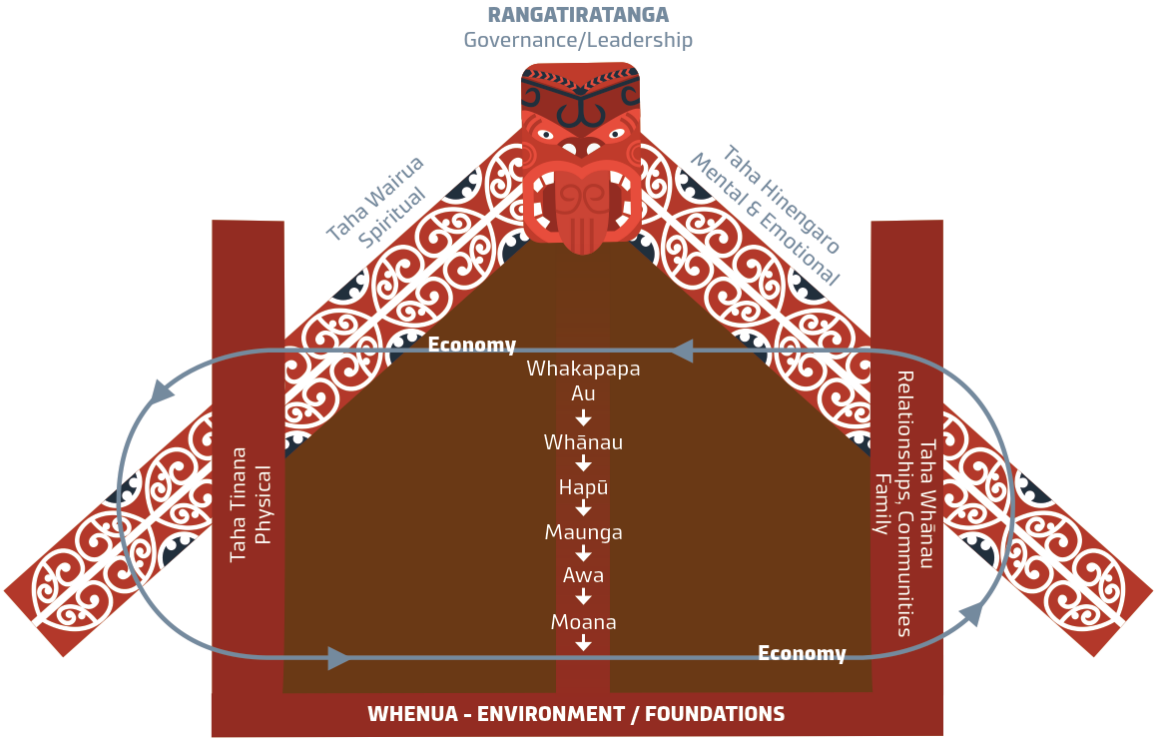

Figure 6-1: Whare Tapa Whā model conceptualising the integrated nature of climate change risks within Mātauranga Māori.

6.4 Risks

The application of the Whare Tapa Wha model in understanding exposure, vulnerability, impact and consequence may enable a holistic approach to assessing risks and their prioritisation. For example, the impact of climate change on māhinga kai may affect all pillars equally, or may be more significant in a particular pillar. While some meeting attendees were able to provide commentary for some of the effects described below, a next step could be a greater understanding of these risks to inform mitigation and adaptation plans for the future. At a broad level, meeting attendees also noted the concern that a region-wide assessment may establish streamlined prioritising and approaches, and that recognising the distinctive Papatipu Rūnanga and hapū risks may be missed.

6.4.1 Marae access and infrastructure

Many of Ngāi Tahu marae and settlements in the Canterbury region are located on the coast and/or within flood prone areas, and therefore highly exposed to sea level rise, coastal erosion and fluvial, pluvial and coastal flooding. Attendees noted a particular interface need with Environment Canterbury's coastal hazard review and sea level rise in the region, and a focus on Banks Peninsula as it relates to Marae and infrastructure. These at-risk communities could also be further impacted by a loss of Tūrangawaewae (a home associated with genealogy) impacting the Taha Hinengaro, Taha Wairua and social domains, as well as reduced property values and insurance increases required to maintain assets.

6.4.2 Māhinga kai

Māhinga kai provide a direct connection to ancestors and genealogy, through collecting food in the same way that ancestors have and connection to particular species and their whakapapa (genealogy). It is the value of natural resources to sustain life, underpinned by the principles of Mana and Manākitanga – the ability to demonstrate hospitality and respect through hosting of visitors and guests. Māhinga kai also enable an exercise of Kaitiakitanga (guardianship) of these resources.

Māhinga kai in Canterbury are diverse and therefore at risk from a suite of hazards including; changes in mean annual rainfall, increased coastal, fluvial and pluvial flooding. Higher air and water temperatures could result in increased temperatures in lake, freshwater, and coastal waterbodies, along with increased ocean acidification.

6.4.3 Cultural landscapes

Cultural landscapes represent whakapapa (genealogy) geographical features, heritage, memories and values of a place. They assist in understanding the connection of people to a place/environment and express Rangatiratanga (sovereignty) and Kaitiakitanga (guardianship) (Reid, 2016). They can be large areas (Te Waihora for example) or as small as a pā. Cultural landscapes are particularly important to the Taha Wairua and Taha Hinengaro. Cultural landscapes are at risk from (but not limited to) sea level rise, coastal erosion, increased fire hazards, reduced snow and ice, changes in mean annual rainfall, impacts on alpine features, and habitat loss for flora and fauna.

6.4.4 Freshwater availability and security

Māori are connected to water and to the whole natural world through whakapapa (genealogy) which binds together the spiritual and natural realms. This lineage descends from Ranginui and Papatuanuku down to people and all parts of the environment. Freshwater, in its many Māori wai forms, are important as sources of māhinga kai, cultural materials (such as hāngi stones), as access routes and a means of travel, and for their proximity to important wāhi tapu, settlements or other historic sites. Some freshwater bodies can also have their own specific mauri (life force) and identity, and they are thought of as ancestors.

Freshwater availability and security are interwoven across all pillars of the whare model as an inherent component to the Taha Wairua, Taha Hinengaro, Taha Tinana, and Taha Whānau. Water supply will be directly affected via decreasing rainfall, and water quality could be impacted by changes in river flow, increased water temperature, and increased sedimentation of water bodies (Landcare, 2019).

6.4.5 Tāonga species

Tāonga species are native birds, plants and animals of special cultural significance and importance to Māori. The significance of tāonga species to Ngāi Tahu is also reflected in many of the rūnanga being named aligned to their tāonga species whakapapa. For example, Kaikōura and Koukourārata. Tāonga

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species have whakapapa (genealogy) intertwined with people. They are used as food sources, medicines, materials for construction and technological development, and a range of other purposes.

Tāonga species are at risk from a range of climatic changes such as drought, flooding and sea level rise. It is also acknowledged that terrestrial, biological and ecological impacts could have flow-on impacts to the food system for people (Landcare, 2019). Attendees at the meeting spoke of the need to address the evolution of tāonga species into the future, as climate change effects are felt and these species are impacted. It was acknowledged that this could have a severe impact on whakapapa (genealogy) and people's connection to place, and therefore seeking out new areas of abundance would be important (as captured in the Climate Change Strategy).

6.4.6 Ngāi Tahu investments

Ngāi Tahu Property holds a diverse portfolio across Christchurch, Dunedin and Queenstown, with a focus on being a long-term investor with inter-generational aspirations. The portfolio includes residential, commercial and industrial built infrastructure and assets. Ngāi Tahu Seafood manages the tribe's investments and quotas in the fishing industry. Attendees acknowledged the deep connection Māori have to the sea, as sea-faring people and navigators, and the rich whakapapa and stories pertaining to the ocean that have been passed down over time. Applying the whare model, Ngāi Tahu investments are seen as providing foundations for the economic sustenance of the iwi.

These varied investment portfolios are at risk from ocean acidification, increased storms and floods, and sea level rise. Changes to economic conditions and the resulting effects on dividend reductions / distribution to rūnanga and whānau may also have socio-economic effects. Ngāi Tahu have begun to invest in alternative modes of energy and sustainable practises to mitigate future effects.

6.4.7 Rangatiratanga and governance

While Ngāi Tahu has a Climate Change Strategy (2018) in place, attendees identified that there is much work to do to raise the understanding of hazards and their impacts within their wider rūnanga and whānau. Combined with this is the need to incorporate holders of Mātauranga Māori in the process at a local level to inform geographic variations within the region, and specific areas of concern of whānau. Attendees also felt that there is a lack of clarity around the complex decision-making that will be required to address climate change across Government and Treaty partners. Advancing these governance matters was seen as critical for Ngāi Tahu, to be able to continue to exercise their rangatiratanga into the future, and to avoid eroding of rangatiratanga from reactionary and/or emergency responses to climate events.

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7 Summary of Risks

From the initial identification of elements, and elicitation from the treaty partner and stakeholders, a long list of elements at risk was established. Consequence for the built, natural, and economy value domains was the scored for each of the elements at risk. The resulting consequence levels for the elements at risk is presented in Figure 7-1 below.

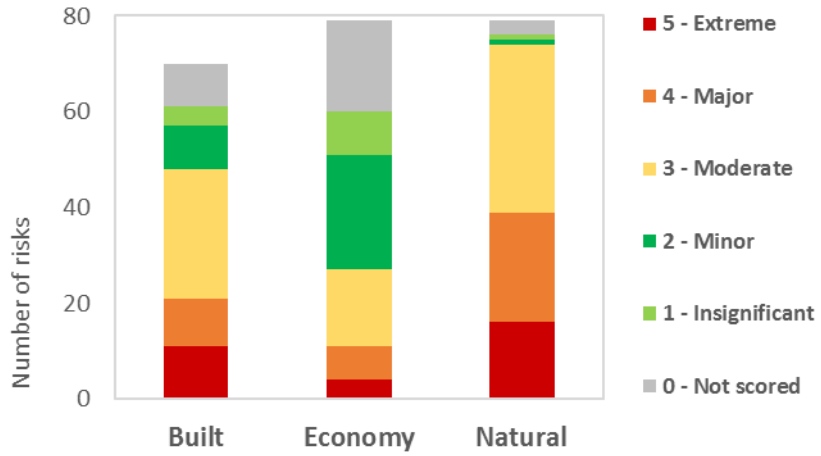

Figure 7-1: Consequence levels of risks across value domains

Figure 7-1 shows that there are a range of consequence levels across the three value domains. For the total elements at risk across the three value domains, 65% are classed as 'moderate' or above, with 30% identified as 'extreme' or 'major'. This 30% of risks form the basis of those elements for prioritisation and further review.

For the built environment, the majority (39%) of elements at risk were identified of 'moderate' consequence. The economy value domain has the lowest risk profile, with 14% of elements at risk identified as 'extreme' or 'major'. The natural environment presented the highest number of 'extreme' and 'major' elements at risk, with nearly 50%. The majority (94%) of elements at risk were identified as 'moderate' or above consequence. These elements at risk were reviewed by the Project Advisory Group, who recognised that some elements at risk appeared to be identified as higher consequence than expected.

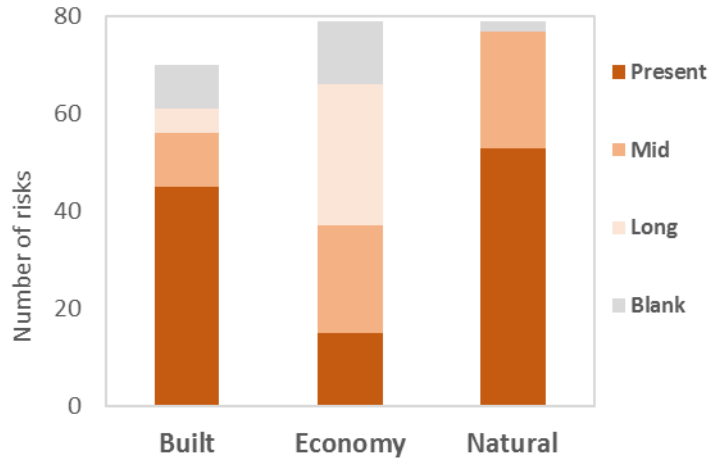

Figure 7-2: Profile of risks across timeframes

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As shown in Figure 7-2, the built and natural environment value domains have substantial identified risks occurring in the present day (65% and 71% respectively). All identified elements at risk were considered to be either occurring now (present day), or will occur during the mid-term outlook (2040). For the economy value domain, over 40% of elements at risk were identified to present during the long-term 2090 timeframe.

While adaptations were discussed during the council staff workshops, only 20% of elements at risk identified to have either existing or planned adaptations. No adaptions (existing or planned) were identified for the natural environment value domain. Climate adaptation across New Zealand is in its infancy - there are many processes occurring that provide climate change adaptation but these may not yet be defined as adaptation activities. Further work is required to document existing, planned and adaptation gaps. This will be completed by Environment Canterbury's project delivery team for the short list of risks described below.

Aggregation of risks

Based on the initial summary of elements at risk (the long list), aggregation was then undertaken by the project team, based on similar elements, hazard exposure, and resulting consequence. This aggregated list of elements at risk is known as the short list of risks. For the human and governance value domains, risks were already grouped at an aggregated level, providing comparison across all value domains. Further narrative about the short list is provided in the following sections. Where possible, this will include information around associated adaptations provided by Environment Canterbury.

The consequence scores for the long list are based on the initial council staff workshop responses, which have been captured as written, with no formal review or update by T+T. For governance and human value domains, elements at risk were identified at a higher level, with a narrative focused discussion (with no consequence scoring applied). Furthermore, a review of identified adaptations will be undertaken for the short-list of risks, described in the following sections.

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8 Priority risks in the built environment domain

This section summarises the prioritised risks identified within the built environment domain. These have been aggregated into representative risk descriptions. Key hazards have been listed, along with their risk rating (extreme/red, or major/orange) as scored in the workshops.

The long list of risks identified in the built environment domain will be included in the final report, and analysis on the proportion of risks by consequence, urgency of risks, and existing and planned adaptations in place will also be provided.

As context for this section, recent assessments completed as part of the Deep South Challenge (NIWA, 2019) have summarised lengths of key infrastructure elements within Canterbury, at risk within various increments above the 1% AEP storm tide level – as shown in the figures below. This shows that there are approximately 750 km of road, 1,800 km of 3-waters pipes, 40,000 buildings, and 75,000 people exposed at 0.9m above the 1% AEP storm tide level.

Figure 8-1: Canterbury Infrastructure, population and buildings exposed at various increments of elevation above the 1% AEP storm tide level

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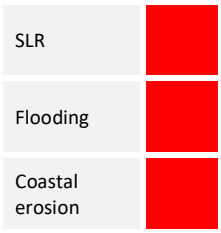
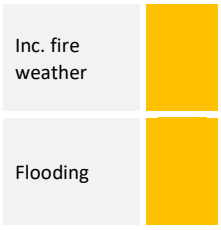
8.1 Settlements and urban communities

A substantial number of settlements and urban communities in Canterbury are located on the coast and within flood prone areas, and are therefore highly exposed to sea level rise, coastal erosion and coastal, and estuarine, fluvial and pluvial flooding. At-risk communities, could be further impacted from reduced property values, insurance retreat, the need to relocate, and many associated economic and social implications.



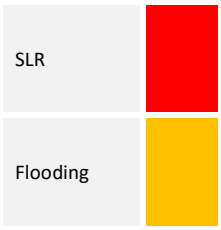
8.2 Rural housing and rural communities

Rural housing and farms could be damaged by increased fire weather and fluvial and pluvial flooding, both of which were deemed major risks. As rural land is converted to forestry, under a low emissions future, rural communities could become increasingly vulnerable due to rural depopulation and the impact on rural employment (Parliamentary Commissioner for the Environment, 2019).



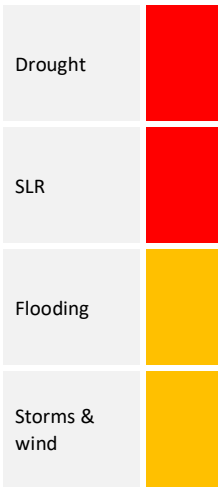
8.3 Stopbanks and flood management schemes

Both stopbanks and wider flood management schemes are deemed to be at extreme risk due to sea level rise and at major risk due to fluvial flooding. Flood management and protection measures could fail (through breach and or overtopping) with increased precipitation intensity and occurrences of flooding, along with sea level rise impacts on coastal structures. Understanding the impact of climate change on flood management schemes, including the standard of protection and impact of sedimentation, is fundamental to reducing risk moving forward.



8.4 Water supply infrastructure

Urban water supplies are deemed to be at extreme risk due to drought and sea level rise, and at major risk due to flooding and storms and wind. Increasing droughts could result in reduced water availability, and increased pressure on supplies as demands increase. There is also evidence to show that severe droughts can impact on wastewater systems, concentration of wastewater flows, which in turn can have adverse impacts within receiving environments (Tonkin + Taylor, 2019). Water supply infrastructure, including pipes, storage schemes and mechanical devices, will also be affected by soil runoff and sediment-induced damage (Bell, 2001). At 1.0 metre of sea level rise, the Canterbury region has exposed water infrastructure valued at more than $630 million, which includes 650 kilometres of water pipes and over 120 pump stations (LGNZ, 2019).



8.5 Irrigation and water races

Irrigation and water races are at extreme risk to drought and changes in mean annual rainfall, and at major risk due to reduced snow melt. The availability of irrigation water will be critical in determining the ongoing viability for crops

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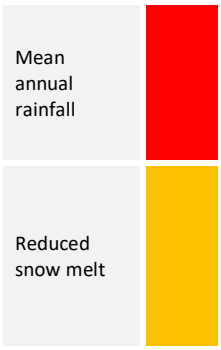
within particular regions, and on certain soils within particular regions (Clothier et al., 2012). Across Canterbury, there is a water race network to supply drinking water to stock animals, and these have secondary purposes as a firefighting resources and source of irrigation. The water race network is thousands of km long in Canterbury, and as these are sourced from rivers and springs, the functioning of the network is at extreme risk due to increasing droughts and changes in mean annual rainfall. In addition to risk of low water supply, sections of the water race network also serve a storm water drainage purpose, and heavy rains may result in increased flooding.



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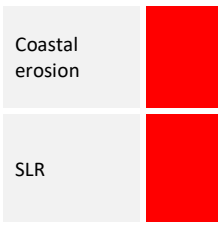
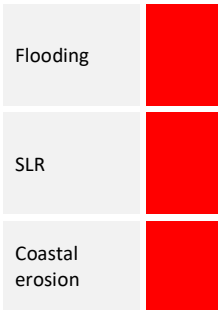
8.6 Wastewater treatment plant

Coastal wastewater treatment plants will be at extreme risk due to coastal erosion and sea level rise. Canterbury has major wastewater assets located in coastal areas, including the Christchurch Wastewater Treatment Plant at Bromley. In Canterbury, nine wastewater treatment plants are exposed to 3.0 metres of sea level rise (LGNZ, 2019).



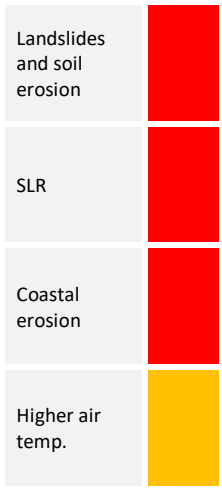
8.7 Roads and bridges

The impact from fluvial and pluvial flooding, sea level rise and coastal erosion on roads and bridges was deemed as extreme. At Banks Peninsula, for example, erosion and/or failure of coastal protection will have an impact on the transport corridor as there is little opportunity to relocate coastal road networks. In Canterbury, 48 bridges are exposed to 1.0m of sea level rise and 646km of road are exposed at 3.0m of sea level rise (LGNZ, 2019).



8.8 Rail

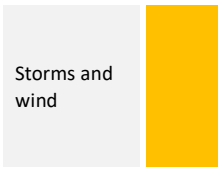
The rail network was deemed to be affected by climate change through increased landslides and soil erosion, sea level rise and coastal erosion, and higher air temperatures. As with roading infrastructure, sections of the rail network in Canterbury are close to the coastline and the failure of coastal protection measures will result in increased vulnerability of rail infrastructure. Higher air temperature also places rail infrastructure at risk; rail heat stress and track buckling currently affects the Kaikōura to Blenheim tracks and this risk could be exacerbated due to climate change (Gardiner et al., 2009).



8.9 Marine facilities

Marine facilities (including ports/marinas, jetties/wharves and boat ramps) across Canterbury were found to be at extreme risk due to sea level rise and at

major risk due to increasing storms and wind. Marine facilities could be at risk due to inundation from sea level rise and infrastructure deterioration due to extreme events, although the degree of impact is uncertain and additional work is needed (Simonson and Hall, n.d.).



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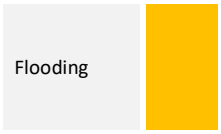
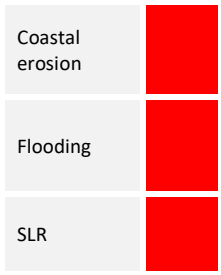
8.10 Airports

The impact of fluvial and pluvial flooding on airports in Canterbury was deemed as major. For example, Christchurch airport is located within the wider Ōtākaro Avon River catchment, and climate change is expected to have a significant impact on the potential for flooding events within this floodplain (Regenerate Christchurch, 2018). This could disrupt airport operations, with flow on impacts to the tourism sector and supply chains.



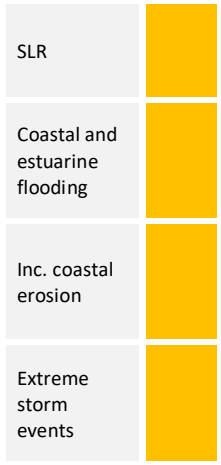
8.11 Landfills and solid waste management, and contamination sites

Solid waste was found to be at extreme risk due to coastal erosion, pluvial and fluvial flooding and sea level rise. In Canterbury, there are five closed landfills and one active landfill exposed to 1.0 metre of sea level rise, and these sites could be at risk of contaminating groundwater or streams (LGNZ, 2019).



8.12 Coastal barriers and sea walls

Coastal defences, such as barriers and sea walls, were deemed to be at major risk due to sea level rise, coastal and estuarine flooding, increasing coastal erosion, and extreme storm events. Coastal defences in Canterbury could be damaged or breached due to these climate hazards, and the impact could be exacerbated by backwater effects or closure of stormwater flap gates from high storm-tide levels (Ministry of Civil Defence and Emergency Management, 2010).



9 Priority risks in the economy domain

This section summarises the prioritised risks identified within the economy domain. Key hazards have been listed, with their risk rating scored.

The long list of risks identified in the economy domain will be included in the final report, and analysis on the proportion of risks by consequence, urgency of risks, and existing and planned adaptations in place will also be provided.

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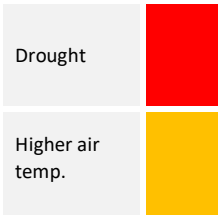
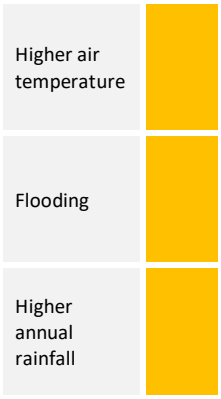
9.1 Livestock

Livestock production will be impacted by increasing droughts and higher air temperatures. Drought was deemed as the highest risk to livestock production in the workshops, and this is in line with findings on the impact of droughts on pasture quality (Renwick et al., 2012). Higher mean air temperatures were also identified as a major risk to livestock production in the workshops. This is confirmed by research showing that higher temperatures may result in decreased irrigation efficiency (due to increasing rates of evaporation) and excessive heat load and increased disease incidence in livestock (Lacetera, 2018; Dairy NZ, n.d.).



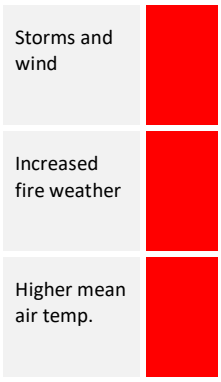
9.2 Crops

The horticulture sector in Canterbury, including potato production and viticulture, was found to be at major risk due to higher mean air temperatures, fluvial and pluvial flooding and higher annual rainfall. The findings from the workshops are confirmed by research which finds that higher temperatures may result in a shortened crop cycle (which particularly affects potato production) and increasingly waterlogged soils can significantly delay crop planning and cause significant crop damage (Clothier et al., 2012).



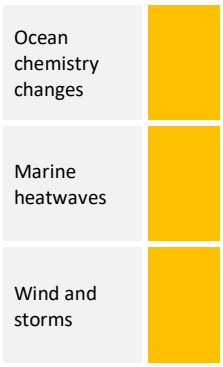
9.3 Exotic forestry

The forestry sector in Canterbury was deemed to be at extreme risk of extreme weather events, such as storms and high winds, and increased fire weather, and at major risk due to higher mean temperature. This is confirmed by research finding that the forestry sector is at risk from increased fire incidence, expected losses in soil carbon (mainly due to the increase in air temperature), and indirect risks due to increased incidence of pests and diseases (Landcare, 2019). There is also a cascading risk on soil erosion due to the impacts of drought, extreme weather events, and high winds on forests (particularly exotic forests).



9.4 Fishing and aquaculture

The fishing and aquaculture industries were found to be at major risk due to ocean chemistry changes, marine heatwaves and wind and storms. Fisheries and aquaculture are important drivers of Canterbury's economy, and ocean acidification is expected to impact on yields due to weaker shells of marine organisms, such as farmed mussels, and increasing wind and storms may impact on ability to access fisheries.[1]



9.5 Tourism

The tourism sector was found to be at major risk due to reduced snow and ice and flooding. Alpine tourism, such as Canterbury's ski fields, is projected to be affected by reducing number of days with snow depths equal to or exceeding ski industry standards. Flooding and extreme weather events have potential to impact on the tourism sector through damaging visitor structures, roads, tracks, buildings, and camp sites.

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[1] FAO 2018 - Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options

10 Priority risks in the natural environment domain

This section summarises the prioritised risks identified within the natural environment domain. Key hazards have been listed, with their risk rating scored.

The long list of risks identified in the natural environment domain will be included in the final report, and analysis on the proportion of risks by consequence, urgency of risks, and existing and planned adaptations in place will also be provided.

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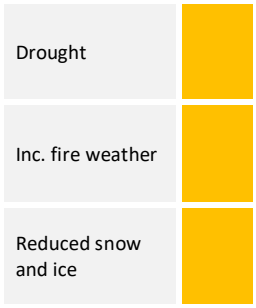
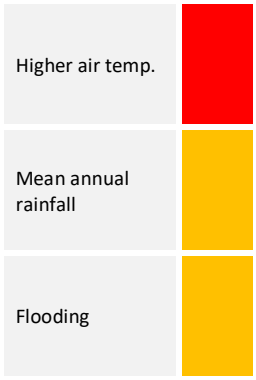
10.1 Native terrestrial biodiversity

Native terrestrial biodiversity in Canterbury was deemed to be at major risk due to drought, increased fire weather and reduced snow and ice. Climate-induced impacts on biodiversity are highly uncertain, but terrestrial biological and ecological impacts could have flow-on impacts to the food system (Landcare, 2019).



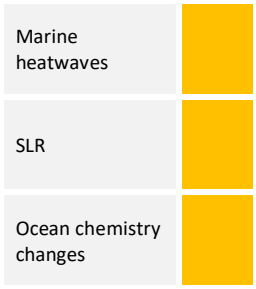
10.2 Native freshwater biodiversity

Freshwater biodiversity was deemed to be at extreme risk from higher air temperatures, and at major risk due to changes in mean annual rainfall and increased fluvial and pluvial flooding. Higher air temperatures in particular could result in increased lake temperatures, which may result in habitat degradation through lake stratification and increased frequency of algal blooms, while Canterbury's rivers could be impacted from changes in river flows (Landcare, 2019).



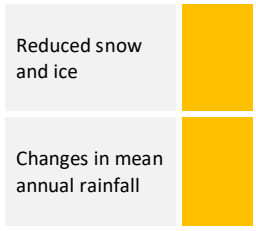
10.3 Native marine biodiversity

Native marine biodiversity was deemed to be at major risk due to marine heatwaves, sea level rise, and ocean chemistry changes. Marine heatwaves may result in changes in species distribution across Canterbury's marine environment, and ocean acidification could weaken shells of marine organisms (Landcare, 2019).

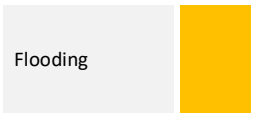


10.4 Surface water availability and quality

The availability and quality of surface water was deemed to be at major risk due to reduced snow and ice, changes in mean annual rainfall, and fluvial and pluvial flooding. Water supply will be directly affected via decreasing rainfall, and water quality could be impacted by changes in river flow,



increased water temperature, and increased sedimentation of water bodies (Landcare, 2019).



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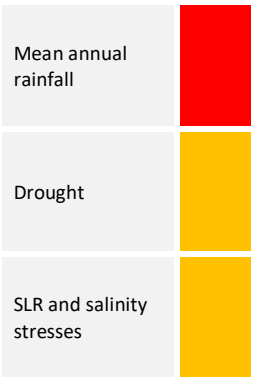
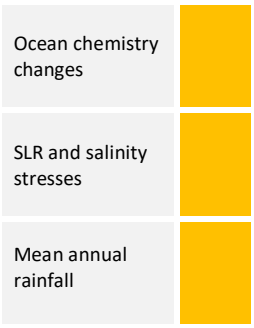
10.5 Groundwater availability and quality

The availability and quality of groundwater was deemed to be at extreme risk due to changes in mean annual rainfall, and at major risk due to drought and sea level rise. Decreasing rainfall and drought will affect groundwater recharge rates, which will have flow on impacts to the agriculture and horticulture sectors, whilst sea level rise and salinity stresses may impact on groundwater quality through increased risk of saltwater intrusion (Landcare, 2019).



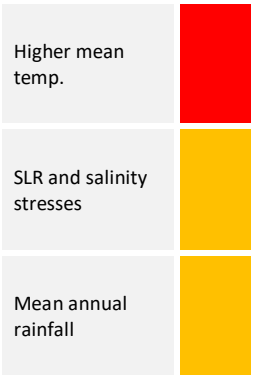
10.6 Water quality in marine, estuary and harbour environments

The water quality of marine, estuary and harbour environments was deemed to be at major risk due to ocean chemistry changes and sea level rise and salinity stresses. Increased sediment loads to estuaries, as a result of increased rainfall, could impact estuary water quality, and marine water quality will be impacted by increased ocean acidification.



10.7 Water quality and quantity (lakes and rivers)

The water quality and quantity of lakes and rivers, including in Te Waihora/Lake Ellesmere, was deemed to be at extreme risk due to higher mean temperatures, and at major risk due to sea level rise and salinity stresses and changes in mean annual rainfall. Higher mean air temperatures, for example, are expected to increase the risk of lake eutrophication and algal blooms, while lakes near the coast will be at risk of saltwater intrusion from rising sea levels (Landcare, 2019).

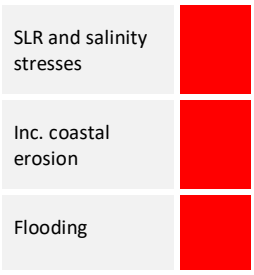


10.8 Natural coastal habitats (dunes, estuaries, rocky shores)

The impact on natural coastal habitats due to sea level rise and salinity stresses was deemed as extreme. Sea level rise will negatively impact coastal ecosystems due to increased erosion of dunes, changing tidal zones of rocky shores, and reduced estuarine water quality – and these factors may drive changes in species distribution and threaten vulnerable populations of coastal species (Landcare, 2019).

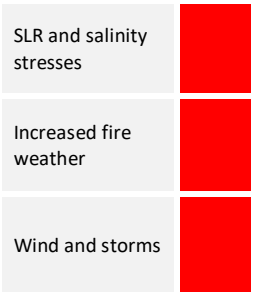
10.9 Coastal wetlands

Coastal wetlands were deemed to be at extreme risk due to sea level rise and the potential for saltwater intrusion, increased coastal erosion, and increased fluvial and pluvial flooding. The water levels of wetlands could increase from sea level rise and flooding, thereby decreasing light levels and negatively affecting vegetation (Landcare, 2019).



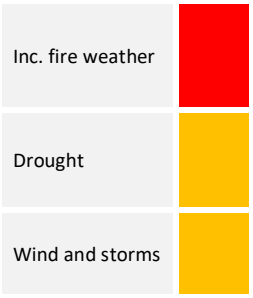
10.10 Lowland and coastal environments

The lowland and coastal environments in Canterbury were deemed to be at extreme risk due to sea level rise and salinity stresses, increased fire weather, and wind and storms. In particular, sea level rise will result in land loss and may lead to more saturated soils beneath the water table and increase the susceptibility to liquefaction during an earthquake (Landcare, 2019). Sea level rise and increased wind and storms will also result in increased coastal erosion.



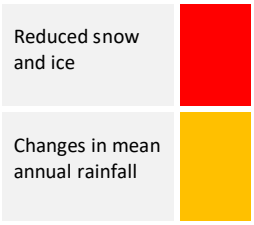
10.11 Montane and hill country environments

Montane and hill country environments were deemed to be at extreme risk due to increased fire weather, and at major risk due to drought and increased storms and wind. Fire risk is predicted to increase across New Zealand, and this is expected to be driven by increased drought, longer fires seasons, and drier and windier conditions making it more difficult to suppress fires (Landcare, 2019). Drought and increasing wind and storms will also result in increased soil erosion.



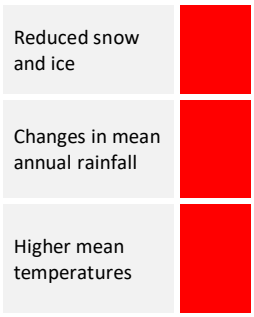
10.12 Alpine and high country environments

The alpine and high country environments of Canterbury were found to be at extreme risk due to reduced snow and ice, and at major risk due to changes in mean annual rainfall. Climate change will impact on alpine features such as tarns, which will result in habitat loss for notable alpine flora and fauna.



10.13 Terrestrial, freshwater, and marine pests and diseases

It was found that there is an extreme risk from increased terrestrial, freshwater, and marine pests and diseases as a result of reduced snow and ice, changes in mean annual rainfall, and higher mean air and marine temperatures. Increasing pests and diseases could have cascading impacts on predator-prey interactions, biodiversity, and agricultural and horticultural production (Landcare, 2019).



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11 Priority risks in the human domain

The impact of climate hazards on the human domain is characterised by both direct and complex indirect (second order, cascading) impacts - affecting individuals, communities and society. Through the elicitation process, direct and indirect risks were characterised and grouped as shown in Figure 11-1. This framework was developed based on the feedback provided in workshops, as a more useful approach to capturing common risk areas.

Figure 11-1: Overview of climate risks in the human domain

As shown in Figure 11-1, human domain risks are broadly defined as follows:

- **Direct health impacts**: Direct health impacts will result from heat stress due to increased mean air temperatures. Individuals at particular risk of heat stress in Canterbury include outdoor workers, vulnerable populations (younger and older people), and households without air conditioning.
- **Indirect health impacts**: There could also be indirect health impacts from climate change. This includes cascading impacts from reduced food security, due to climate impacts on agriculture and food supply chains, which may compromise nutritional outcomes of some groups. There could also be a risk from vector-borne diseases (e.g. dengue and Ross River virus) and food and water borne diseases resulting from increasing air temperatures and rainfall and fluvial and pluvial flooding.
- **Psychosocial impacts**: The impact of climate change on the wellbeing of vulnerable individuals, households, communities and all populations. This includes farmers (who face a high risk of financial failure), rural communities in general, individuals with disabilities and those pre-disposed to mental illness, and younger populations (who could face climate anxiety). The impacts of climate change are also likely to exacerbate the vulnerability of individuals, households, and communities impacted by the 2010 and 2011 earthquakes in Canterbury.
- **Impacts on social fabric and community**: This includes impacts on the rural-urban divide, difficulties with resettling people (including individuals relocated from coastal regions and international climate refugees), and the impact of community upheaval and change (which may challenge social capital).

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- **Impacts on community capacity and resilience**: Highly vulnerable communities, such as lower socio-economic communities and coastal communities, will be at risk of reduced capacity and resilience. This may result through increased frequency and magnitude of disruption or impact – both physically, socially and economically.
- **Equity impacts**: This includes potential impacts from increasing costs of living, and how climate change will impact the most vulnerable populations (including coastal communities, and households with low access to resources).
- **Agency capability impacts**: This related to the capacity and capability of councils, government agencies and NGOs to respond to climate change impacts within communities that may be new to them. This may call for new skills, or increases in resources, dealing with a range of migrant communities, people with complex needs etc.

Vulnerable populations were also discussed within the workshops. Attendees felt that identifying these populations was useful to explore more fully – especially in subsequent stages. The following factors were identified as assisting in identifying vulnerable populations.

- Low-income and high levels of debt;
- Disabilities and pre-existing mental health conditions;
- Older and younger people;
- Poor access to health services;
- Lower levels of education;
- Populations previously impacted by shocks, such as Canterbury earthquakes and flood events;
- Uninsured or precariously insured;
- Households, neighbourhoods and communities with low access to natural capital, such as tree coverage (which provides shade and soil stability);
- Climate change refugees, and other refugees.

A number of direct risks were also captured during the workshops, and were given an initial consequence ranking. The extreme and major risks are summarised in Table 11-1 below.

Table 11-1: Summary of extreme and major *direct* risks in the human domain

Element	Climate hazards	Direct risk description	Consequence
Coastal communities	• River flooding • Sea level rise • Coastal erosion	Large coastal communities are unique to Canterbury. Sea level rise may make coastal communities uninhabitable.	Extreme
Rural communities	• Temperature • Reduced land supply (due to managed retreat elsewhere)	Farming and rural communities highly impacted – high risk of financial failure for farmers.	Extreme
Direct health impacts	• Heat stress • Impact on food Extreme weather • Floods	Vulnerable populations more at risk (younger and older people, homeless population, and households without air conditioning). Increase in food insecure population. Increased deaths in vulnerable populations, including younger and older people.	Extreme

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Indirect health impacts	• Increased temperature • Climate change	New diseases and illness.	Major
Psychosocial impacts	• Drought and floods for rural communities • All climate hazards	At risk groups more vulnerable - these include farmers, those with a mental illness, and young people (b/c of climate anxiety). Need to support communities to plan for uncertainty (and be aware cultures may respond differently).	Extreme
Ability to work outdoors	• Increased temperature • Extreme events	Reduced productivity; increased exposure to heat stress.	Major
Marae, Urupa, Wahi Tapu, Taonga	• Increased rainfall • Flooding • Sea level rise • All climate hazards	Impact of SLR on marae; coastal inundation of food beds; and impact on rock art.	Major
Ability to practice Tikanga Maori	• Ocean impacts • All climate hazards	Increasing water temperature impacting on Mahinga kai and taonga species.	Major
Infrastructure servicing sites of cultural importance	• Sea level rise • Flooding	Disruption to access to sites of cultural importance.	Major
Community capacity and resilience	• Extreme weather events	Unequal distribution of, and access to, resources. Increased cost of living, and changing labour market.	Extreme
Social fabric of community/In equity	• Sea level rise • Extreme weather events	Less social capital due to relocation of households and communities, and increases in inequity.	Major
Agency capability impacts	• Sea level rise • Extreme flooding • Migration (climate refugees)	Relocation of coastal communities. Resettlement challenges (multicultural integration).	Extreme

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12 Priority risks in the governance domain

In general, the current policy, regulatory and legal systems in Canterbury and New Zealand are viewed as not being adequate for undertaking a timely, effective and just response to climate change[2]. The workshop participants were of the view that the current governance responsibilities are unclear, there is a lack of jurisdictional and legal liability clarity, and that decision making is expected to become increasingly complex due to climate change.

Climate change could also result in impacts on the ability to fund and maintain infrastructure (including infrastructure such as climate resilient roads and buildings) and delivery of public services (including emergency planning, police, and community facilities). The effectiveness of local government planning and the functioning of the banking and insurance systems could also be impacted, which will result in major impacts to community and society.

Based on the workshops with councils, the following actions were considered important for strengthening governance outcomes:

- Recognise the impact of climate change on wellbeing;
- Develop a geospatial understanding of risks, as risks will vary across Canterbury;
- Provide a climate strategy (both mitigation and adaptation) that informs the Long Term Plan (LTP), 30 Year Infrastructure Plans, Civil Defence Plans, and Regional and District Plans, Strategies and Policy Statements;
- These should be based on the guidance and requirements within the proposed Climate Change Response(Zero Carbon) Act;
- Current legislation lacks alignment and needs urgent review in this regard – including The Local Government Act, the Resource Management Act, and the Building Act.

The major and extreme risks impacting the governance domain are outlined below in Table 12-1.

Table 12-1: Summary of risks in governance domain

Element	Climate hazards	Risk description
Emergency planning and response, and recovery operations	• Flooding • Erosion • Storms • Fire • Heat waves	Base systems are currently in place for emergency planning and response, but systems for responding to heat waves and fires are at present inadequate. Also, climate hazards will negatively impact emergency recovery operations
Ability to fund and maintain infrastructure and public services	• All climate hazards	Climate hazards will negatively impact the ability to fund and maintain infrastructure and public services – this includes water supply and agriculture/irrigation. The increased need for adaptation funding will have significant impact on council budgets.
Functioning of planning rules and policies	• All climate hazards	Climate hazards will negatively impact on the functioning of planning rules and policies.
Insurance and banking system	• Sea level rise • Erosion	Impact of climate hazards on insurance availability. Higher risk to banks, due to mortgage timeframes.

[2] Refer Climate Change Adaptation Technical Working Group Options Report (2018)

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	• Flooding • Droughts • Increase in fire weather	
Functioning of social service agencies	• Disease • Heat waves • Droughts • Sea level rise	Increased burden on social service agencies.
Functioning of police	• Floods • Increase in fire weather • Extreme weather events	Increased resources required for emergencies, and the potential for exacerbating social unrest.
Jurisdictional issues	• Dependent on hazard	Lack of jurisdictional clarity of councils and public agencies.
Legal liability	• Especially coastal erosion, sea level rise and flooding	Risk of increased legal liability of councils and public agencies.
Community facilities	• Flooding, sea level rise, and coastal erosion	Impact of climate hazards on community facilities and events.

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13 Opportunities

Opportunities across the five value domain were identified from the workshops held with councils, Ngai Tahu and the CCCWG. Key opportunities are summarised in this section.

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13.1 Built environment domain

Canterbury may see the following opportunities in the built environment as a result of climate change.

Table 13-1: Climate opportunities in the built environment domain

Sector	Opportunities
Waste	Improved design – i.e. moving to a circular economy.
Wastewater	Wastewater ponds will work better with warmer temperatures.
Energy	Increased use of renewable energy (wind, tidal, decentralised solutions etc.), as Canterbury transitions to a low-carbon energy system, which could result in strengthened energy security and independence and improved air quality. Possibly improved wind resources, due to increased wind conditions. Opportunity to share lessons globally to catalyse other countries' transition to low-carbon energy systems.
Energy Efficiency	Incentivising improved energy efficiency.
Public transport	Reduction of emissions through strategic transport policy. Social benefits from community interaction, which could improve community integration.
Electrified transport	Electrification of transport.
Urban	Opportunity to achieve urban regeneration, and future-proof infrastructure, as urban areas are developed as climate resilient.
Housing	Opportunity to build better planned communities and construct climate resilient housing.
Water	Harvesting of rainwater for drinking water, which will result in less pressure on centralised sources and storm water discharges.

13.2 Economy domain

Canterbury may see the following economic opportunities as a result of climate change.

Table 13-2: Climate opportunities in the economy domain

Sector	Opportunities
Agriculture	More self-sufficient, and opportunity to grow new higher-value crops. Also longer growing season, higher production, and efficient and sustainable land use. Change in growing season will result in different farming practices (which could lead to decreased methane emissions from moving to low carbon food production). Potential to improve irrigation and water storage, and opportunities to use higher flowing rivers (if increases in rainfall occur).
Manufacturing	Technological opportunities, improved innovation, and new alternative products. Opportunities to manufacture low-carbon products locally in Canterbury.
Innovation	Creativity, innovation, increased resource efficiency – which will create opportunities for society to move away from business as usual to a circular economy.

Tourism	Increased tourism due to increased summer season, and changing climates across the seasons.
Construction	Rebuilding of infrastructure and residential housing from climate proofing infrastructure and relocation of communities.
Fisheries	New marine fish species migrating, resulting in fishing opportunities.
Carbon trading	Increased value from offsets. If native trees are used, there is an opportunity for improved biodiversity, as well as less erosion and better fire resilience and flood protection.

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13.3 Natural environment domain

Canterbury may see the following opportunities in its natural environment as a result of climate change.

Table 13-3: Climate opportunities in the natural environment domain

Sector	Opportunities
Land use	More productive land, native afforestation/revegetation (resulting in mitigation and biodiversity benefits). Planting of fire resistant species.
Water	Water quality improvements due to reduced pastoral farming.
Ecosystem-based adaptation[3]	Opportunity to use nature based solutions for adaptation and mitigation, and enhancing nature for responding to climate change.
Flooding	Endowment of top-soil post flooding events.

13.4 Human domain

Canterbury may see the following opportunities in the human domain as a result of climate change, and initiatives that may be the result of transition to a low carbon and energy efficient economy.

Table 13-4: Climate opportunities in the human domain

Sector	Opportunities
Health	Public health benefits from cycling and walking, and transitioning to a more plant-based diet.
Education	Increased awareness of natural environment. People expect more sustainable approaches from themselves, their government and from the commercial businesses that supply goods and services for sale.
Liveable cities	Benefits from warmer homes in winter – including less heating cost for houses, and reduced health impacts. Also benefits from other green initiatives such as urban afforestation, green roofs, increased provision of shade, planning for cooling centres, and improved access to safe public drinking water etc.
Youth leadership	Preparing young people for a new world, and fostering youth leadership.
Social inequity	If climate change can be addressed, opportunity to improve social conditions.
Population	Population growth (climate refugees) may result in increased economic growth/opportunities.

[3] Ecosystem-based adaptation involves the conservation, sustainable management and restoration of ecosystems to help people adapt to the impacts of climate change.

13.5 Governance domain

Canterbury may see the following opportunities in the governance domain as a result of climate change.

Table 13-5: Opportunities in the governance domain

Sector	Opportunities
Community	Opportunity for community involvement in decision making. Empowering communities, demonstrating care in how agencies work with communities. Building communities that are more resilient, equitable, and connected.
Funding	Access to new funding sources for responding to climate change – such as the Green Investment Fund.
Planning	Sea level rise could result in re-thinking of land use planning, and the way we build cities/communities (increasing density). Planning to not use land in volatile areas, i.e. flood prone areas. This land can be re-vegetated, afforested etc.
Decision-making	Brave, courageous and kindness-led decision-making by authorities. Opportunity to enhance alignment across agencies and sectors.
Just transition	Ensuring that the transition to a low-carbon economy is managed, and opportunities are available to households, communities, industries and the Canterbury region. Transitioning in partnership with iwi, regions, sectors, communities and vulnerable populations, and placing climate justice at the core of the transition.
International	NZ will be affected less by climate change than other countries, which may result in economic and trade opportunities.

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14 Transition risks

The transition of New Zealand and Canterbury to a lower-carbon economy will require extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change (TCFD, 2019). There is high uncertainty over what this future will entail in New Zealand, but the current changes proposed in the Zero Carbon Act and modifications to the New Zealand Emissions Trading Scheme highlight the scale of the changes to be expected. Depending on the nature, speed, and focus of these changes, transition risks may pose varying risks to Canterbury councils, businesses, and other organisations. In the workshops with councils, the transition risks summarised in Table 14-1 were identified as being significant.

Table 14-1: Summary of transition risks for Canterbury

Risk	Risk description
Shift in social license for high carbon industries/activities	• Lower tourist numbers (e.g. due to decreased air travel); • Job losses, economic impact to community; • New industries and innovation; • Less demand for farming products (e.g. dairy, sheep and beef products).
Decline in certain industries, and rise in others. There will be an impact on workforce	• Decline in carbon intensive industries (e.g. oil and gas and agriculture); • Changes in food systems – and with high employment in agricultural sector in Canterbury, impact could be significant; • Job training, re-skilling required. Impacts on unskilled people, and could result in forced migration (rural to urban drift).
Unmanaged transition to climate resilient low emissions economy	• Isolation of people using outdated technology; • Social inequity impacts from an unjust transition; • Providing subsidies (potential for adverse economic consequences from picking 'winners' and 'losers').
Increase in low emissions vehicles	• Impact on electricity supply and infrastructure; • Battery disposal/management; • Affordability/accessibility/availability of electric vehicles; • Redundant fossil fuel infrastructure and failure to use existing vehicles; • Traffic congestion from increased uptake of electric vehicles rather than investment in public transport.
Increasing investment in public transport	• Potential for low demand due to low population density, consumer preferences etc; • High cost to users; • Need longer distance options for rural communities; • Potential for lack of public support.
Increasing afforestation (exotic and native)	• Risk of increasing exotic forestry – trade off with native forests, social resistance, reduced water catchment and decline in groundwater (if selected tree species are water depleting); • Degradation of soil quality; • Increased forest fires; • Loss of productive farmland, and potential for low employment in rural Canterbury.
Increasing carbon price	• Make some industries unviable; • Increased price for consumers; • Also, opportunity to sell carbon credits offshore.

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Low carbon requirements for exporters	• Higher cost products, potentially less competitive internationally; • Risk of leakage – business moving to countries with lower operating costs.
Agricultural emissions pricing (land-use changes)	• Risk around just transition of farmers (financial impact to rural communities); • Balancing agricultural land with carbon sequestration.
Increase in supply of renewable energy	• Availability of renewable resources – e.g. water for hydro systems; • Infrastructure capacity, generation capacity (few opportunities for hydro generation left); • More focus on other technologies needed (i.e. wind and tidal); • Potential negative impacts from renewable energy adoption (i.e. land use, biodiversity impact, changes in river flow due to hydro); • Reliability – need for baseline generation, storage of renewable energy, impact of increased wind speeds on wind energy generation.
Changes to NPS on Renewable Electricity Generation	• Challenge to consents, and issues with planning process; • Perverse impacts – i.e. relying on biofuels; • Impacts on water quality, quantity, and biodiversity.
Enabling high density urban planning through the Urban Growth Agenda and NPS on UDC	• Community acceptance – what does high density look like for Canterbury?; • Risk of creating poor quality housing/neighbourhoods; • Not having sufficient infrastructure in place.
Increasing cost of waste disposal	• Issues with disposing electric vehicle batteries; • Coastal landfills – may require moving landfills; • Risk of dumping and illegal disposal.
Technological changes	• Difficulties disposing of old low-carbon technology; • Substitution of existing products and services with low emissions options, cost of transitioning to low emissions technologies; • High cost of low-carbon technologies – cost-benefit ratio; • Moral hazard from overreliance on technology.
Market for low carbon goods and services	• Changing consumer preferences; • Flight shaming, reduced demand for tourism sector and pastoral sector; • Gap between desire and capacity to change.
Impact on vulnerable communities	• Marginalization of climate vulnerable households and communities; • Impact of managed retreat on coastal communities.
International impacts	• Imported emissions (embedded emissions) and risk of leakage (companies leaving NZ to jurisdictions with lower operating costs); • International price shocks impacting on NZ economy.

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15 Summary of risk screening

For the built environment, economy and natural environment domains, the risks identified as major and extreme are included in this report. These risks are described based on the associated climate hazards and the impact of the risk on the region. For the risks across these three value domains, 65% are classed as at 'moderate' or above risk, with 30% identified as 'extreme' or 'major' risks.

For the built environment, the majority (39%) of elements at risk were identified of 'moderate' consequence. The economy value domain has the lowest risk profile of these three domains, with 14% of elements at risk identified as 'extreme' or 'major'. The natural environment presented the highest number of 'extreme' and 'major' elements at risk, with nearly 50%.

The human and governance domains were described at a higher-level, as these domains are characterised by both direct and complex indirect (second order, cascading) risks – affecting individuals, communities and society, and the functioning of the policy, planning and legislative processes.

In addition to the physical risks identified in this screening, a number of transition risks were identified across the domains. These risks were not scored by consequence or disaggregated across timeframes. The risk screening also resulted in a number of opportunities being identified across value domains, which are also important as these can allow for improved planning by Canterbury councils.

16 Conclusion / next steps

This screening assessment forms the first part of a broader risk assessment process, which also involves a detailed risk assessment and development of an adaptation plan as per the NCCRA Framework process.

The CCCRS is a high-level screening across the five value domains. In the next stages of the risk assessment process, climate risks for Canterbury can be understood further across the five value domains and in a more locally relevant manner. This could include completing further research on the at-risk elements, especially those lacking evidence on possible climate impacts, which will help to reduce the level of uncertainty associated with assessing climate risk.

Another potential avenue going forward is developing an improved understanding of the spatial nature of the climate risks facing Canterbury. Where it is possible to ascertain the spatial impact of climate change across the value domains, this information will be able to be used to target adaptation responses, however will not be possible for all risks.

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17 References

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18 Applicability

This report has been prepared for the exclusive use of our client Environment Canterbury, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that this report will be used by Canterbury councils in undertaking its regulatory functions.

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Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
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Appendix A: Methodology

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Aligning with the NCCRA Framework, the CCCRS methodology looks to establish risks and opportunities at a regional level. This will provide a broad understanding of climate change associated risks and opportunities for Canterbury, which can then be understood further during later stages of the wider risk assessment process.

This section documents the overall method undertaken to establish risks and opportunities for the CCCRS, along with detailing associated assumptions.

A1 Physical risk screening

To screen for physical climate change risks, the following steps were taken:

6 Establishment, review, and validation of elements per sector and value domain;

7 Identification of existing and future climate risks based on RCP8.5 (long list);

8 Screening of identified risks for impacts (as a function of exposure and vulnerability);

9 Screening of impacted risks for consequence (where it was possible);

10 Screening of existing and planned adaptation actions (where it was possible);

This was achieved through an initial desktop study, followed by an elicitation process with council staff.

A1.1 Sector and element identification

An initial 'long-list' of elements was established for each sector and associated value domain, based on a desktop study of the literature review (Landcare, 2019) and other specific information, as required. The identified sectors align primarily with those identified within the ongoing NCCRA process. Where relevant, specific climate hazards associated with elements identified were noted.

These risk elements were reviewed, validated, and challenged during workshop sessions with council staff, who focused on specific value domains. This provided a finalised 'long-list' of risk elements within specific sectors and value domains.

A1.2 Elements at risk

Following establishment of elements, workshop participants identified key climate change hazards associated with each element, providing a longer list of 'elements at risk'. Given the time available, generally the top three climate change hazards for each risk element were identified.

A1.3 Screening elements at risk for impact and consequence

To screen for impact and consequence, matrices from the NCCRA Framework were adapted to be relevant for the Canterbury region. Impact was documented across three timeframes (present, 2040, and 2090) as a binary process (yes / no). A single consequence score was then given for each element at risk. This process was applicable for the physical risks, and taken forward for the elicitation process, discussed below. This process was completed by workshops attendees in breakout groups, focusing on each value domain.

A1.4 Screening for adaptation

During the workshops, council staff (and other academics in attendance) were asked to document any adaptions for specific elements at risk. This included 'existing' and 'planned' adaptions. Where

no known adaptations exist, workshop participants documented a 'gap'. The information provided during this process was reviewed

A1.5 Ranking of risks

In the workshops, risks were ranked across the value domains based on the consequence scores identified (insignificant to extreme). To further rank risks within each consequence score, we used a weighting based on timeframe, which involved assigning a higher weighting to risks that are identified to impact during the present day above those risks that only impact in the long-term.

In this report, we have summarised a list of the prioritised extreme and high risks, which forms the short-list of risks, in line with the NCCRA Framework. Risks were short-listed based on the ranking completed in the two one-day council workshops, the subsequently reviewed by the CCCWG. Commentary from this review was then incorporated into the project team desktop review, and a subsequent aggregated 'short-list' of risks was established. This involved aggregating the risk elements into higher-level groupings based on the risks deemed most regionally consequential to Canterbury. This included grouping of specific climate change hazards within the aggregated short list.

The short-listed risks have been further assessed in the following sections of this report, and a summary of major and extreme risks is provided across the value domains.

A2 Identifying and documenting existing and future opportunities

While the CCCRS process focuses heavily on risk identification, it is important to recognise that there will likely be opportunities for Canterbury's economy, society, and environment as a result of the impacts of climate change. During each workshop, possible opportunities were identified associated with the physical impacts of climate change and transition changes from moving to a low-carbon climate resilient economy. Physical climate change hazards were associated to each opportunity, where applicable (i.e. longer growing season as a result of changes in seasonality).

While consideration of opportunities is an important part of the screening process, as it can allow for improved planning by Canterbury councils, the focus of the screening was primarily on risks, aligned with the NCCRA Framework.

A3 Transition risks

A list of transition risks, provided by Environment Canterbury, was used during both full-day workshops to provide participants with an initial list to review, validate and challenge. Any additional transition risks identified were documented, with commentary captured around the potential impacts associated with transition to a low carbon future. Again, these were reviewed during the CCCWG, with results provided within the report.

A4 Assumptions and limitations

It is recognised that this CCCRS is a fundamental step for Canterbury to understand climate change risks and opportunities. This broad screening process provides an initial stock take of the climate change risks over varied timeframes, and will allow for future work to be undertaken in a structured and prioritised manner. The broad nature of this study results in assumptions and limitations, however many of these can be further interrogated with subsequent work. The fundamental limitation of this approach relates to the granularity of the assessment. While there is a drive to understand the impacts of climate change at a highly detailed, local level, it is not possible to achieve this at the screening stage. This will emerge during a more detailed risk assessment of the prioritised risks, which could include (for instance) a more detailed spatial analysis of prioritised regional risks.

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A part of this work, a number of assumptions were required. These are listed as follows:

- There is deep uncertainty about the state of technology, economic structure of Canterbury, and the policy and regulatory environment in 2040 and 2090. Therefore, the screening of future risk was based on the best existing knowledge of future states of the world across the five value domains.
- One of the key challenges in this screening was understanding how exposure and vulnerability will evolve in the future, as New Zealand faces increasing risks and social-economic adjustments from climate change and policy responses to mitigating greenhouse gas emissions. This screening therefore only involved a high-level qualitative assessment, allowing further narratives to be introduced and appraised in future iterations. The first assessment will not involve the use of different future scenarios, such as the Shared Socioeconomic Pathways (SSPs) (Frame et al, 2018).
- No regional downscaling of climate projections are available for Canterbury and as such this risk screening was based on the national modelling (MfE, 2017).The accuracy of the screening was, therefore, constrained by the quality and granularity of the hazard data available.
- It is also assumed that climate risk screenings will be conducted on a periodic basis as new information and data is available. This screening approach has been based on the information made available at the start of this project, detailed above.
- Screening of planned and existing adaptation actions were based on the information elicited in the workshops, and there are significant gaps. We will continue to work with the CCCWG to understand adaptations better for the prioritised short-list of risks.

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Appendix B: Relevant risk taxonomy

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Taxonomy within climate change risk is complex with a multitude of conceptual models and sets of terms, parameters and definitions. Taxonomy within this report follows that of the NCCRA Framework and the IPCC (2014) Report. The key terms are listed below.

- Adaptation (of climate change) – The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).
- Adaptive capacity – The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
- Consequence - The outcome of an event that may result from a hazard (NCCRA, 2019). It can be expressed quantitatively (e.g. units of damage or loss, disruption period, monetary value of impacts or environmental effect), semi-quantitatively by category (e.g. high, medium, low level of impact) or qualitatively (a description of the impacts) (NCCRA, 2019).
- Exposure – The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).The number, density or value of people, property, services, or other things we value (taonga) that are present within an area subject to one or more hazards (i.e. within a hazard zone), and that may experience potential loss or harm (NCCRA, 2019).
- Hazards – The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts (IPCC, 2014).
- Resilience: The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014).
- Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. In this report, the term risk is often used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure (IPCC, 2014).
- Transition changes – The process of changing from one state or condition to another in a given period of time, in this case transitioning to a low-emissions future (adapted from IPCC, 2018).
- Vulnerability – The predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm or damage, and lack of capacity to cope and adapt (IPCC, 2014).

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