Manaaki Whenua
Landcare Research

NGĀ PAE O TE
MĀRAMATANGA
Flourishing Māori Futures

He huringa āhuarangi, he huringa ao: a changing climate, a changing world

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He huringa āhuarangi, he huringa ao: a changing climate, a changing world

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Contents

He Whakarāpopoto – Summary iv
1 Kupu Whakataki – Introduction 1
2 Tikanga Mahi – Investigative Framework and Analysis 2
2.1 Arotake Tūraru – Risk Assessment 4
3 Kaupapa Māori Risk Assessment: He Kura Taiao – Living Treasures 6
4 Kaupapa Māori Risk Assessment: Whakatipu Rawa – Māori Economy 18
5 Kaupapa Māori Risk Assessment: He Oranga Tāngata – Healthy People 28
6 Kaupapa Māori Risk Assessment: Ahurea Māori, Tikanga Māori – Māori Culture and Practices 36
7 Whakarāpopototanga – Summary 45
8 Ngā mihi – Acknowledgements 46
9 References 46

He Whakarāpopoto – Summary

Kaupapa – Issue

Iwi/hapū governance institutions are increasingly asserting their rangatiratanga to manage climate change risks and safeguard the well-being of whānau/hapū/iwi. However, there is a shortage of guidance specifically for whānau/hapū/iwi on mitigating and adapting to climate change, with most existing guidance targeted towards central and local government agencies.

Te Whainga – Objective

This report summarises the latest research and guidance on observed and projected climate change impacts on whānau/hapū/iwi and Māori business in Aotearoa-New Zealand (Aotearoa-NZ). It considers the implications of climate change for diverse Māori interests and investments, and provides commentary on risk and uncertainty, knowledge gaps, and options for mitigation and adaption.

Tikanga Mahi – Methodology

Work described in this report draws on the consequence (risk) assessment framework and methods used in the first National Climate Change Risk Assessment led by the Ministry for the Environment. Overlaying this framework, we applied a Kaupapa Māori analytical approach that affirms the importance of Māori self-definitions and self-evaluations. We compiled risk scores for four domains of interest: He Kura Taiao – Living Treasures, Whakatipu Rawa – Māori Enterprise, He Oranga Tāngata – Healthy People, Ahurea Māori, Tikanga Māori – Māori Culture and Practices.

He Arotake Tūraru – Risk Assessment

He Kura Taiao – Living Treasures: Freshwater, terrestrial and coastal-marine ecosystems and biodiversity in Aotearoa-NZ are likely to be affected by projected warming temperatures and changing precipitation patterns. Vulnerable flora and fauna will face habitat loss and, in some cases, extinction. It is expected that any obstruction to accessing keystone species will adversely impact Māori customary practice, cultural identity, social cohesion, and well-being. Some hapū/iwi are engaging with whānau to identify aspects of climate change having the greatest impact and creating pressures, while others are developing comprehensive hapū/iwi plans that articulate Māori values, tasks and aspirations regarding climate change risks and wider natural resource management. However, there remains a need to better understand how different ecosystems and keystone species are at risk, and how climate-induced changes are likely to affect the varying interests, goals, responsibilities, health, and well-being of whānau/hapū and iwi in different places. Addressing the risks of climate change to natural ecosystems and biodiversity will require political commitments to ensuring high environmental standards and more sustainable living arrangements, as well as deeper consideration of the rights of future generations.

Whakatipu Rawa – Māori Enterprise: Changing climatic conditions are expected to present diverse risks to Māori capital, enterprise and employment. Over 68% of Māori businesses are in the primary sector, where climate change impacts are likely to be significant. Large proportions of Māori land are already experiencing high rates of erosion. Over 80% of Māori land is defined as hilly-to-mountainous and is susceptible to major erosion events such as landslides. Extreme rainfall events associated with climate change are likely to exacerbate the problem, and future-proofing this land is critical. Māori are also soon to own nearly 40% of commercial forestry plantations, which are vulnerable to climate extremes such as high-intensity storms, droughts and wildfires. More frequent and severe droughts, particularly across eastern and northern areas of the country, are very likely to affect production yields and product quality in Māori forestry, farming and horticulture operations. Māori investments in the fisheries sector are also significant (Māori own 33% of quota by volume). Nearly half of these investments are in potentially at-risk species like pāua, kōura and hoki. Overall, changing climatic conditions are expected to adversely impact the natural assets of the Māori economy. Due diligence will be required by whānau/hapū/iwi to better understand the risks and opportunities, and create strategies that include divesting risky assets and adopting new production systems and practices.

He Oranga Tāngata – Healthy People: It is expected that Māori will be disproportionately affected by climate-change-related health impacts, although impacts will vary between communities and be influenced by geographic location, socio-economic status, existing health conditions, health system capability, and the capacity to adapt. Direct impacts on health include increased exposure to potentially harmful weather events such as heatwaves and floods. Indirect effects include reduced water availability and quality. Impacts on water are likely to be greatest where reticulated supply systems are poorly developed (or absent altogether), and where communities lack the resources to import water or pay for private treatment facilities. Other indirect impacts include the arrival of new infectious-disease vectors such as mosquitoes, disruptions to health services and food security, housing and livelihood stresses, and health inequalities. A number of public health initiatives are needed to help whānau/hapū/iwi prepare for and cope with the health impacts of climate change. These include reorienting the health sector towards areas where climate change will have the greatest impact and ensuring that interventions reduce social and health inequities. Any health policy that addresses climate change risks for Māori must be based on an understanding that whānau/hapū/iwi health is dependent on the stability of social-economic arrangements and, more fundamentally, on the well-being of natural systems.

Ahurea Māori, Tikanga Māori – Māori Culture and Practices: Climate-induced changes to the natural environment in Aotearoa-NZ are expected to fundamentally alter the way Māori interact with that environment, each other, and other communities. Sea-level rise and the consequent displacement of whānau/hapū/iwi from coastal areas are likely to interfere with the transmission of Māori language and customary lore, and such outcomes are expected to have implications for Māori identity, social cohesion, and well-being. Other Māori communities are disproportionately at risk because valued domestic and cultural infrastructure, such as marae and urupā, are

located on exposed, erosion-prone lands (e.g. low-lying coastal areas and/or river valleys). Climate-change-induced extremes such as floods, fires and droughts also pose risks for convening and delivering Māori cultural festivals and sporting events. It will be essential to incorporate climate change considerations into plans and devise strategies for managing future disruptions and/or cancellations. Whānau/hapū/iwi will need to consider adaptation strategies that protect the integrity of Māori language and customary lore, future-proof existing cultural infrastructure and provide flexibility. Such strategies must safeguard the ability of whānau to engage in social/cultural activities that enhance well-being and ensure an enduring cultural legacy.

Ngā Kupu Ārahi – Future Work

The work undertaken in this report emphasises diverse climate change risks, vulnerability and adaptive capacities across Māori society. It also makes clear that changing climatic conditions are likely to exacerbate many of the existing stresses and inequities facing whānau/hapū/iwi, and that there is a need to understand climate change risks from Te Ao Māori perspectives. Future work, such as integrated assessments, must help those grappling with the challenges and uncertainty of climate change to combine multiple types of information and knowledge into adaptation plans. Urgent work is also needed to better understand the social, cultural, and fiscal implications of sea-level rise, including what duties local and central government have with respect to actively upholding Māori interests under the Treaty of Waitangi. In association with these organisational and governance challenges, it is likely that intergenerational approaches to climate change planning and policy will become increasingly important. Future work must elevate political discussions about conceptions of diversity that recognise non-human entities with rights in law, and challenge the way people manage, relate to, use, and value the natural world and its resources.

1 Kupu Whakataki – Introduction

Māori governance institutions are increasingly asserting their rangatiratanga to manage climate change risks and safeguard the well-being of whānau/hapū/iwi. However, there is a shortage of guidance specifically for whānau/hapū/iwi on mitigating and adapting to climate change. Most existing guidance targets central and local government agencies. While many Māori organisations have the capacity to manage their own interests and activities, information as well as approaches to understand the implications of climate change for mitigation and adaptation decision-making are often not available or have not been clearly demonstrated. To facilitate more enduring decisions, Māori organisations need a clearer understanding of climate change impacts and their implications for whānau/hapū/iwi interests, development, and well-being. Whānau/hapū/iwi also need guidance to make informed decisions that address climate change in a manner that reflects Māori views and values.

By collaborating across multiple entities, including the National Science Challenges, Ngā Pae o te Māramatanga (NPM) has assembled a multidisciplinary team of Māori researchers to explore climate change mitigation and adaption solutions for Māori. This report thereby summarises the latest research and guidance on observed and projected climate change impacts on whānau/hapū/iwi and Māori business in Aotearoa-NZ. It considers the implications of these impacts on diverse interests, and provides commentary about risk and uncertainty, knowledge gaps, and options for mitigation and adaptation. The report is intended to supplement the first National Climate Change Risk Assessment (NCCRA) (AECOM 2020). However, it should not be regarded as an exhaustive summary on this topic, but rather a sweep of recent developments.

Figure 1. Waipapa Marae. Image: The University of Auckland.

2 Tikanga Mahi – Investigative Framework and Analysis

The work undertaken in this report draws upon the framework and methods used in the first NCCRA (AECOM 2020). The objective of the NCCRA is to help inform priorities in the forthcoming National Adaptation Plan by central government and in regional adaptation plans by local government.

Using the value domains from the NCCRA as a starting point, we considered the latest research and guidance surrounding observed and projected climate change impacts before assessing the specific risks facing whānau/hapū/iwi and Māori business. The NCCRA outlines five value domains for assessing climate risks and opportunities: Human, Natural Environment, Economy, Built Environment, and Governance. These domains represent groups of values, assets and systems that may be at risk from exposure to climate-related hazards, or may be beneficially affected by climate-related changes. The NCCRA gives some consideration to risks facing whānau/hapū/iwi and Māori business. However, the first-order level of the assessment did not permit a deeper analysis of impacts, implications and risks facing different Māori interests, values, and activities.

In this study, attention is given to the following four domains:

- He Kura Taiao – Living Treasures
- Whakatipu Rawa – Māori Enterprise
- He Oranga Tāngata – Healthy People
- Ahurea Māori, Tikanga Māori – Māori Culture, Māori Values and Principles

The NCCRA addresses healthy people within its Built Environment domain, alongside healthy homes. However, we considered human health (He Oranga Tangata) as a standalone domain, given it is often overlooked in climate change assessments. Further, evidence suggests climate-related adverse health impacts will become more severe and be borne disproportionately by groups like Māori who already suffer health inequities. We cover the Built Environment component of the NCCRA in our Whakatipu Rawa and Ahurea Māori, Tikanga Māori domains, where we reference the risk to cultural infrastructure (e.g. marae and wāhi tapu) from climate change.

We did not explore the Governance domain as there is currently limited evidence available to support a risk assessment. In terms of Treaty of Waitangi partnerships, please refer to Iorns (2019) as a starting point for exploring Treaty duties relevant to adaptation to coastal hazards from sea-level rise.

The at-risk domains on which we focus are presented in Figure 2.

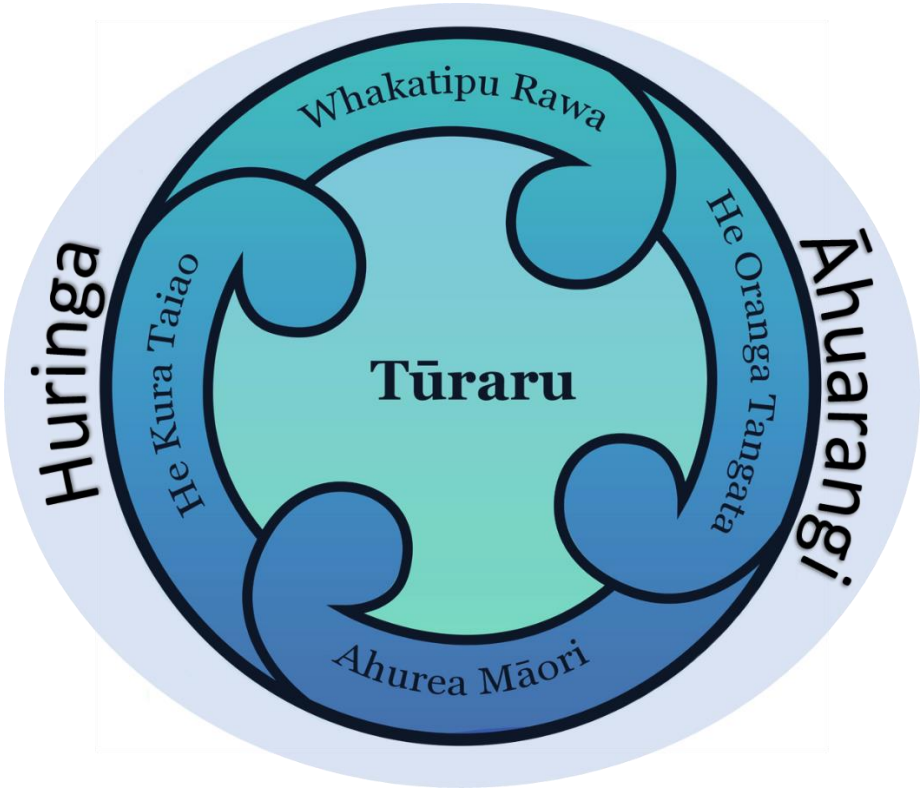

Figure 2. Huringa Āhuarangi Kaupapa Māori.

Figure 3. Pikopiko. Image: Manaaki Whenua, Bradley White.

2.1 Arotake Tūraru – Risk Assessment

We assessed the risk facing whānau/hapū/iwi and Māori business utilising the elements of **hazard**, **exposure,** and **vulnerability**, with the overlap defining the risk (see Fig. 4) (Oppenheimer et al. 2015). Risk is a function of climate hazards (which can be physical *events* or *trends,* such as episodic flooding, landslide or erosion events, or longer-term sea-level rise), the degree to which things we value are exposed to the hazard (people, assets, taonga), and their vulnerability to its effects. Vulnerability is influenced by socio-economic status, physical characteristics, cultural processes, and tikanga Māori (including adaptation and mitigation actions and governance), which can increase or decrease the consequences (and therefore the risk) resulting from exposure to a hazard (Ministry for the Environment 2019a).

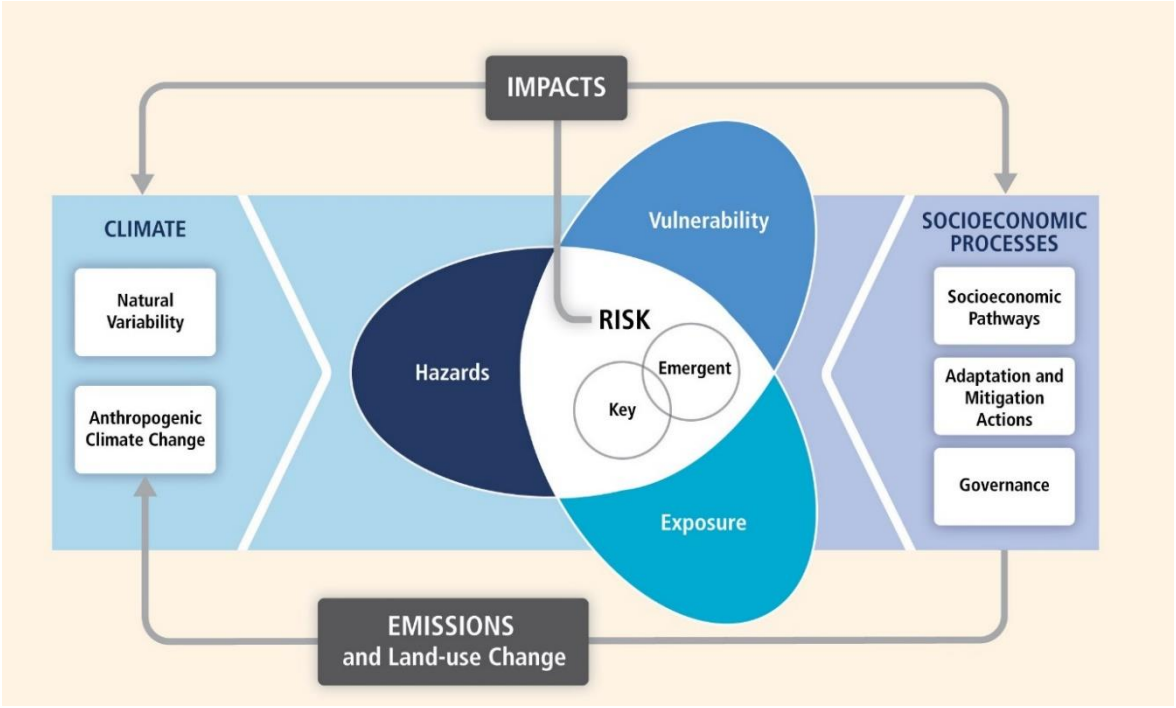

Figure 4. Schematic of the interaction between the physical climate system, exposure, and vulnerability producing risk (Oppenheimer et al., 2014, p. 1046).

The rating of risk is based on a consideration of the hazard, exposure, and vulnerability and utilises the qualitative assessment scale developed by the NCCRA. The five levels of risk range from 'Insignificant' to 'Extreme' and a description for each is provided in Table 1.

Overlaying this framework, we applied a Kaupapa Māori analytical approach that affirms the importance of Māori self-definitions and self-evaluations (Smith 2005). NPM climate change researchers conducted risk assessments using a consensus-based expert judgement approach. They compiled risk scores for each of the domains of interest (He Kura Taiao – Living Treasures, Whakatipu Rawa – Māori Enterprise, He Oranga Tāngata – Healthy People, Ahurea Māori, Tikanga Māori – Māori Culture and Practices).

Table 1. Risk (consequence) rating scale (MfE, 2019a)

Insignificant	No significant change in impact nationally that can be handled through business-as-usual processes or some local or regional impacts with no specialised management required
Minor	Some minor impacts at the national scale that could be addressed through local or regional management and adaptation processes
Moderate	Significant impacts at the national scale of interest to national agencies to address adaptation, or a major impact for 1–2 sub-national climate zones
Major	Major impacts at the national scale of high interest to national agencies to quickly address adaptation, or an extreme impact for 1 sub-national climate zone
Extreme	Extreme impacts at the national scale (or even in a few sub-national climate zones) of heightened interest to national agencies to urgently address adaptation. May be of interest to international partners or financial or insurance institutions

Subject experts identified components of interest for each domain. Using the He Kura Taiao domain as an example: contemporary ecological assessments generally consider the impacts of climate change on tree species of interest from a biosecurity perspective. However, using a Kaupapa Māori approach, the assessment explores how climate change will impact the physical, social, and spiritual connection that Māori have with the natural environment. Similarly, a contemporary economic analysis typically focuses on the risks to investment in various assets like production forests and fisheries quota. We framed our analysis holistically, considering, for example, the risks to whānau in harvesting cultural keystone species for sustenance and maintaining manaakitanga. We expanded each domain into a number of components of interest, and determined risk scores and identified potential adaptation strategies for each component.

3 Kaupapa Māori Risk Assessment: He Kura Taiao – Living Treasures

This section summarises the latest research covering observed and projected climate change impacts on natural ecosystems in Aotearoa-NZ. It considers how these impacts will affect diverse Māori interests, and provides commentary on risk and uncertainty, knowledge gaps, and options for protection, restoration, and adaptation. To enable the review, we divided natural ecosystems into terrestrial, freshwater, and coastal-marine domains. These domains comprise living and non-living parts that derive and provide services[1] through relationships that are integrated, produce feedbacks, and depend on context and scale, from the mountains to the sea. Importantly, this framing reflects that people are embedded in and part of these ecosystems and are only borrowing the resources from generations yet to come. A risk assessment (Table 2) is given for this domain at the end of this section.

Terrestrial Ecosystems

Many terrestrial ecosystems in Aotearoa-NZ, from alpine, lowland, and coastal forests to tussock grasslands and pasture, are under pressure from land-use change, fragmentation, pollution, introduced predators, invasive plants and pests, and changing climate conditions (McGlone & Walker 2011; Reisinger et al. 2014; Renwick et al. 2016; DOC 2020). This century, incremental as well as abrupt changes in climate are expected to exacerbate these pressures, challenging the production and ecology of indigenous and managed flora and fauna and, in some cases, exceeding rates of evolutionary adaptation (Reisinger et al. 2014; Renwick et al. 2016). The well-being, care, utilisation, and management of terrestrial ecosystems are of paramount importance to whānau/hapū/iwi and Māori business, and any adverse impacts on such ecosystems and the services they provide are expected to impact economic, social, and cultural values across Māori society (Penny et al. 2007a, 2007b; King et al. 2010; Paul et al. 2016).

Recent reviews of alpine, sub-alpine, lowland, and coastal forests indicate that these diverse ecosystems are likely to be modified and altered by direct as well as indirect changes in climate regimes (Halloy & Mark 2003; McGlone & Walker 2011; Bond et al. 2019; DOC 2020). Some tree species will find more suitable habitats beyond their current geographic ranges (e.g. in more southern latitudes and/or at higher altitudes as the climate warms), while other species will not be able to move and will find their current habitat increasingly unsuitable. Warming that results in a loss of alpine habitat is very likely to have a major impact on indigenous biodiversity, particularly if it eliminates isolated patches of alpine terrain or opens these areas up to new and invasive species. Halloy and Mark (2003) estimate that between 40 and 70 species of indigenous plants will be at risk of extinction due to climate-induced rising tree lines and the spread of closed woody vegetation. If mean annual temperatures reach 3°C above present, they predict loss of about 80% of the discrete alpine areas in Aotearoa-NZ, and extinction of between 200 and 300 species of indigenous vascular plants, or up to half the alpine total. There is some

[1] Ecosystem services are supported by biodiversity: the animals (includes humans), plants and micro-organisms that have adapted to, and interact within, ecosystems (Roberts et al. 2015).

evidence that recent warming has already resulted in rising treelines (e.g. beech) and the adaptation adjustment of certain plant communities (e.g. herbaceous, grasses, tussocks) in Aotearoa-NZ (Harsch et al. 2009). Notwithstanding these risks, some native tree species, such as tōtara and rimu, are reasonably tolerant of warmer temperatures and different habitats and these biophysical characteristics are likely to provide a degree of resilience in the face of changing climate regimes, at least in the short to medium term (Bergin & Kimberley 2003; McGlone & Walker 2011; Ryan 2017). Any obstruction to accessing keystone cultural species from indigenous terrestrial ecosystems due to climate change (as well as failure to meet obligations to other species and provide for future generations) is very likely to adversely impact and/or transform Māori customary practise, cultural identity, and well-being (King et al. 2010; Jones et al. 2014; Bond et al. 2018;[2] DOC 2020).

Shifts in seasonal and minimum temperatures that result in less snowfall, and fewer and less-severe frosts, are also very likely to alter the timing of flowering and the abundance of insect pollinators, which could adversely impact some plant species and strongly affect some ecosystem functions (McGlone & Walker 2011; Renwick et al. 2016). For example, warm temperatures and drought promote excessive honeydew production in mountain beech and kāmahi forests, which can lead to increases in Platypus beetle and subsequent damage to mature trees that can transform forest structure (Wardle 1984). The loss of flowers and new growth could also have significant implications for Māori commercial interests in horticulture, such as honey production from pōhutukawa and mānuka (Teulon et al. 2015; Lambert et al. 2018). Similarly, the quality of medicinal (traditional/rongoā and modern) products from key species may be compromised (Lambert et al. 2018). Forest ecosystems (both indigenous and managed) are also likely to be affected by cascading climate-induced interactions with introduced herbivores and weed species, and the consequences of such changes are potentially significant for threatened and rare terrestrial ecosystems (Renwick et al. 2016; DOC 2020).

Changes in temperature and rainfall patterns are also expected to lead to increased annual fire risks, with significant implications for the protection of indigenous and managed terrestrial ecosystems and species (Reisinger et al. 2014; Renwick et al. 2016). Most terrestrial ecosystems across Aotearoa-NZ have evolved without fire and are not adapted to it, and most native tree species cannot survive even low-intensity fire (Kitzberger et al. 2016; Tepley et al. 2018). Once burned, the smaller trees and shrubs that are the first to inhabit burned spaces are more prone to burning than the taller, closed-canopy beech forests. Coupled with other factors such as loss of seed sources or invasive plants, forest

[2] Bond et al. (2019) undertook species distribution modelling to explore climate risks for the plant species kūmarahou and kuta that are used for medicinal and weaving purposes, respectively. Based on projected changes in temperature and precipitation their study showed that the growing suitability for kuta will likely shift to the south, while the range of kūmarahou will likely expand into higher latitudes. When combined with knowledge of tribal boundaries and cultural practices, the authors concluded that the decreasing suitability for kuta in Northland is likely to inhibit local kuta availability and the continued use of harvest sites that have been utilised for generations. Reduced local access to species is also expected to have implications for the loss of tribal knowledge and therein cultural identity and connections to the environment. In contrast, as the growing suitability for kūmarahou increases regionally, it is likely this will alter gifting practices as access and harvesting expands and changes.

recovery may take centuries if it happens at all (Tepley et al., 2018). Projections for drier conditions in the northern and eastern parts of Aotearoa-NZ point to increasing fire risks for indigenous and managed forests across these regions (Pearce et al. 2005, 2011; Reisinger et al. 2014; Renwick et al. 2016). Māori have substantial investment in forestry across these regions (King et al. 2010). The increased spread of exotic conifer forests might also exacerbate fire incidence and have consequences for threatened and rare ecosystem types (McGlone & Walker 2011).

Figure 5. Korimako, Orokonui Ecosanctuary. Image: Manaaki Whenua, Bradley White.

In terms of managed terrestrial ecosystems, some exotic forests, horticultural crops, and agricultural grasslands may benefit from longer growing seasons and more atmospheric carbon dioxide (CO_2) stimulating plant and pasture growth. Further, there may be new opportunities connected with warming temperatures, such as the expansion of current horticultural and agricultural ranges to new areas (Stroombergen et al. 2008). However, periodic drought, erosion, and flood events, as well as invasive pests, pathogens, and weeds, pose significant risks to the production rates of some crops (Reisinger at al. 2014; Renwick et al. 2016). For example, as projected west–east coast rainfall gradients become more pronounced, growth rates of economically important plantation forests (mainly *Pinus radiata*) are expected to increase in the south and west of the country, while growth reductions are more likely for the east of the North Island (Hennessy et al. 2007). Given the location of most Māori forestry land at present, this is likely to disproportionately affect Māori investment on the east coast (King et al. 2010). Similarly, Māori investment in horticulture is highest in the kiwifruit industry in the eastern Bay of Plenty. Projected periods of sustained low or no precipitation in this region are expected to make surface

water supplies scarce, affecting groundwater recharge and potentially affecting harvest and crop yields, forcing land managers to rely more heavily on groundwater where it is available. Storm events and sustained periods of heavy rain, coupled with sea-level rise, could also reduce the ability of drainage systems and other infrastructure to handle flood events on near-coastal agricultural lands (Reisinger et al. 2014). Such impacts not only pose risks for tribal investments in dairy and beef and lamb production but also challenge those tasked with finding new sustainable investments to undertake due diligence regarding climate change risks (Smith et al. 2017; Te Rūnanga o Ngai Tahu 2018). The regions most at risk are likely to be those currently at the edge of climate tolerance, those already stressed by economic and social and biophysical conditions, and those where long-term investments have been made that restrict adaptation options (King et al. 2010).

Projected warming of regional climate regimes is expected to affect the ranges of some indigenous and introduced faunal species in Aotearoa-NZ (McGlone & Walker 2011; Bulgarella et al. 2014; Walker et al. 2019). For example, Bulgarella et al. (2014) mapped the distributions of two tree wētā species (*Hemideina crassidens* and *H. thoracica*) using a combination of climatic and ecological data and concluded that changes in the altitude range of these species were forced by a mix of warmer temperatures and competition with other wētā. Similarly, invasive predators are very likely to expand their ranges in response to climate change, potentially accelerating local extinctions of already predator-vulnerable birds, reptiles, invertebrates, and plants (Walker et al. 2019). For instance, warmer, drier winters might extend the distribution ranges and breeding seasons of rodents, goats, pigs, possums, and rabbits, leading to increased browsing pressure on indigenous trees, shrubs, and herbs. The increased numbers of these mammals also act as food sources for feral cats and ferrets that are damaging to native birds, lizards, bats and wētā (Smith & Jamieson 2003; Nugent et al. 2001; Pryde et al. 2005; Hoare et al. 2007; McGlone & Walker 2011).[3] Meanwhile, paper wasps and ants are the major introduced invertebrate predators in Aotearoa-NZ and have been implicated in the reduction of indigenous invertebrates through direct predation, and in reducing bird populations through competition for food and attacks on nestlings (Clout & Lowe 2000; Beggs 2001). These introduced species are highly responsive to climate conditions, so it is likely that their abundance and distribution will increase in a warming world (McGlone & Walker 2011). As noted, any failure to meet obligations to other species and provide for future generations places at risk the natural order of the environment, and in turn the health and well-being of whānau/hapū/iwi (King et al. 2010; DOC 2020).

Numerous actions would help whānau/hapū/iwi and Māori business support the protection, restoration, and sustainable management of terrestrial ecosystems, taonga species, and already stressed or degraded ecosystems in the face of direct and indirect climate change impacts. Some of these actions include improving understanding of ecosystem management objectives from whānau/hapū/iwi and Māori business perspectives; implementing monitoring practices (based on mātauranga Māori and

[3] Mast seeding events have an important influence on mammalian predators in Aotearoa-NZ. More frequent masting events stemming from warmer summer days could result in higher numbers of predators and the extinction of some threatened indigenous flora and fauna (McGlone & Walker 2011; DOC 2020).

science) that provide for the early detection of invasive species on land[4]; improving understanding of biodiversity-climate linkages and culturally significant ecosystems and taonga to help prioritise activities to manage and restore culturally important terrestrial ecosystems and habitats; developing new approaches to ecosystem utilisation, protection, and management that draw upon differences in social-cultural values utilising a range of knowledges (mātauranga Māori and science). Assessing the suitability of tribal lands for afforestation/reforestation schemes that could help to harness the multiple functions of forests, from supporting biodiversity and ecosystem services to carbon capture and controlling erosion might also contribute to lessening climate change risks for terrestrial ecosystems and biodiversity (Harmsworth 2003; Funk & Kerr 2007; Harmsworth et al. 2010; Warmenhoven et al. 2014).

Freshwater Ecosystems

Many freshwater ecosystems in Aotearoa-NZ, such as rivers, streams, lakes, and wetlands, are degraded and under substantial pressure (Costello et al. 2010; McGlone & Walker 2011; Roberts et al. 2015). Increasing human populations, land-use change and habitat loss, as well as the emergence and establishment of new pests, diseases and pathogens are widely cited as key drivers of degradation and decline in freshwater quality and biodiversity. While the impacts of changing climatic conditions on freshwater ecosystems in Aotearoa-NZ are difficult to establish, projected warming of the global climate system and shifts in hydrological conditions are expected to increase the stresses faced by many freshwater ecosystems (Reisinger et al. 2014; Renwick et al. 2016). The well-being, care, utilisation, and management of freshwater ecosystems are of paramount importance to whānau/hapū/iwi, and any adverse impacts on these ecosystems, cultural keystone species, and the services they provide are expected to impact social-cultural values and economic interests across Māori society (Penny et al. 2007a, 2007b; King et al. 2010; Warmenhoven et al. 2014; Paul et al. 2016; Te Rūnanga o Ngai Tahu 2018; AECOM 2019).

Based on the latest climate projections for Aotearoa-NZ, as ambient air temperatures rise over this century, particularly in the north-eastern regions of the country, the temperatures of many freshwater ecosystems are also expected to increase (MfE, 2018). These increases are very likely to alter freshwater habitats critical to many cultural keystone species, and in some cases may even lead to localised extinctions. For example, freshwater fish species, such as longfin eels, that develop in streams and live in the ocean as adults before returning to spawn may be vulnerable because they have evolved within certain temperature ranges (Egan et al. 2020). Changes in seasonal temperatures might even influence the movement of some fish populations to higher elevations, as well as change migration timing and success. However, considerable questions and uncertainties remain

[4] The Māori Biosecurity Network demonstrated that Māori kaitiaki (local environmental guardians) are the best 'eyes on the ground', and with community networks are best placed to identify the first signs of new pathogens within indigenous forests. Within 5 months of the first incursion of the fungal plant disease Myrtle Rust (*Austropuccinia psidii*) onto mainland Aotearoa-NZ, the Māori Biosecurity Network had trained over 100 kaitiaki to identify Myrtle Rust and report suspected Myrtle Rust finds (Lambert et al. 2018).

about the ecology and life-histories of many freshwater taonga species, including their sensitivities to different climate variables.

A recent pilot project assessed the vulnerability to climate change of 10 freshwater taonga species (eight fish and two invertebrates) by ranking the sensitivity attributes and exposure variables of each species under two future climate change scenarios (Egan et al. 2020). Expert species assessors selected climate exposure variables based on environmental parameters known to affect each species, and the availability of environmental data. While their work revealed substantial gaps in knowledge about the effects of climate change on Aotearoa-NZ's freshwater taonga species, it concluded that longfin eels, lamprey (piharau, kanakana), īnanga, kōaro, banded kōkopu, the shortfin eel and the freshwater mussel are highly vulnerable species. Notwithstanding these conclusions, exposure of taonga species to climate change is expected to vary nationally and the response of each species will depend on their location and unique set of characteristics (e.g. spawning duration or dispersal abilities) (Egan et al. 2020).

Figure 6. Tuna: NIWA (Rohan Wells).

Changes to river flow regimes as a result of increases or decreases in precipitation may also alter migratory cues for migratory fish species (Egan et al. 2020). It is likely that fish requiring specific rainfall regimes and water-level changes will have limited tolerance for projected changes in the frequency, intensity, and predictability of precipitation. Shifts in hydrological conditions due to changing rainfall regimes, compounded by nutrient

loading from urban and rural lands, could also make conditions in freshwater lakes and wetlands more suitable for algal blooms that degrade water quality and create health risks for aquatic life, other animals, and humans (Renwick et al. 2016). Warmer and drier summers are also projected to reduce some lake levels and raise water temperatures, which strongly influence the growth of cyanobacteria and harmful algal blooms (Roberts et al. 2015). Such impacts are likely to challenge Māori utilisation of these ecosystems for fishing, hunting and recreation (Penny et al. 2007a, 2007b). Further, any obstruction to accessing cultural keystone species and other resources is very likely to adversely impact customary practice, cultural identity, and well-being[5] (Jones et al. 2014; Warmenhoven et al. 2014; Bond et al. 2019).

Many Māori communities are seeking knowledge and tools to help restore degraded freshwater ecosystems and associated taonga, at various scales, to provide for intergenerational cultural, social, environmental, and economic needs. Māori voices from all corners of the country have made clear that climate adaptation strategies for freshwater habitat protection, restoration, and enhancement should focus on kaitiakitanga and involve families, communities, and other entities (King & Penny 2006; MfE 2007; Stephenson 2012).[6]

Actions might include: enhancing riverbank and lakeside vegetation to stabilise and buffer areas against nutrient runoff, erosion and sedimentation, and/or provide shade and cool water for freshwater species implementing monitoring practices that provide early detection of invasive species in freshwater ecosystems; expanding initiatives that support the control and manual removal of invasive plants and animals assisting the migration of vulnerable animal species to suitable habitats, and increasing funding and incentives for private landowners to manage lands and connected waterways in ways that enhance ecological and economic resilience. Further, governance-related adaptation options might include innovative collaborative management structures with local and regional authorities, Māori-imposed standards on resource allocation and use, and cultural state-of-the-environment reporting (Harmsworth 1997).

To respond to and prepare for changes in climate, and the effects of those changes on freshwater ecosystems, more understanding is needed about species (e.g. taonga) vulnerability to climate change. Future research that would greatly assist includes understanding the responses of aquatic ecosystems to multiple interacting stressors, predicting degradation from cumulative effects and prioritising activities to restore degraded habitats. The development of Māori cultural indicators and values for assessing

[5] Often misunderstood is the degree of reciprocity that underpins the relationship between the health of our freshwater ecosystems, taonga species, and the well-being of whānau, hapū, and iwi. The late Te Huirangi Waikerepuru from Taranaki argued that it is a lack of respect, honour, and protection of the 'natural order' of the environment that compromises the well-being of these systems on which all people depend (King et al. 2010).

[6] Other voices highlight the importance of the role of the Treaty of Waitangi when developing climate change policies that affect Māori, Government obligations to Māori under Treaty settlements, and the need for equity in setting mitigation and adaptation goals to minimise unfair, or unintended, consequences for different communities and groups (MfE 2007; Stephenson 2012; Jones et al. 2014; Paul et al. 2016; Jones 2019).

aquatic ecosystem health, mauri [life-force, condition], and climate change is essential, including criteria for determining standards in culturally and ecological important areas.

Coastal-Marine Ecosystems

The coastal-marine area is Aotearoa-NZ's largest ecological domain. It comprises coastal lagoons, estuaries, and harbours as well as inshore and open ocean ecosystems. Researchers are already detecting climate-related changes across many of these ecosystems. Among the most significant, sea levels are rising and coastal-marine environments are becoming warmer and more acidic (Law et al. 2018; MfE & Stats NZ 2019). Changing climate regimes are also allowing new pests and diseases to emerge and establish, driving changes in the distribution of species and modifying the relationships between indigenous flora and fauna (Reisinger at al. 2014; Renwick et al. 2016; DOC 2020). These changes are very likely to be exacerbated by land-sourced sediment and nutrient runoff, as well as by existing risks to the sustainability of wild fisheries across Aotearoa-NZ (Hurst et al. 2009).

Warming sea- and land-surface temperatures have directly affected some coastal-marine flora and fauna (Wernberg et al. 2016; Thomsen et al. 2019; DOC 2020). For example, during the 2017/18 marine heatwave, high sea-surface temperatures in southern Aotearoa-NZ led to the complete loss of rimurapa [bull kelp, *Undaria*] at some reefs in Lyttleton, and a significant loss at four other sites (Wernberg et al. 2016). The kelp is used by Māori to make pōhā [food storage containers] for preserving, steaming and transporting food such as tītī [mutton bird]. At locations where the kelp was lost, an invasive, non-native kelp took its place and researchers observed a dramatic decrease in mussels (Thomsen et al. 2019). Further, a recent study found that warming seas around the Otago Peninsula have reduced the survival rates of hoiho [yellow-eyed penguins], likely because the fish on which they feed are fewer and of lower quality. Other factors, such as disease outbreaks, predators, and tourism have played a role, but high sea-surface temperatures make it increasingly difficult for such seabird populations to recover from a variety of pressures (Mattern et al. 2017). Species-specific studies are needed to understand if, and how, changing oceanic conditions are affecting different coastal-marine species. As noted, any failure to sustain species, especially cultural keystone species, will have deleterious consequences for Māori socio-cultural values and cultural identity. Climate change is therefore expected to undermine mātauranga Māori [tribal knowledge] by severing the connection to certain species in climate-driven environmental contexts (Penny et al. 2007a, 2007b; King et al. 2010; Warmenhoven et al. 2014; Paul et al. 2016; Te Rūnanga o Ngai Tahu 2018; Bond et al. 2019).

Wild fish stocks are also influenced by variations in climate. Sightings of out-of-range tropical and warm-water fish are increasingly common across Aotearoa-NZ (Salinger et al. 2019). Further, there is evidence that warmer seas are affecting the reproduction of some important commercial and customary marine species such as kōura, paua, and hoki (Dunn et al. 2009). These observations are of concern for Māori as a significant proportion of Māori fisheries assets by value are concentrated in these species (Rout et al. 2018). Snapper is also an important commercial and customary species for Māori, but research indicates there are both opportunities and threats associated with increasing water temperatures and ocean acidification caused by climate change (Parsons et al. 2014).

While changing ocean temperatures may result in a southward shift of some tropical species and present new opportunities for the fisheries industry in Aotearoa-NZ, the present lack of information about the vulnerability of wild fish stocks (e.g. scampi, tarakihi, gurnard, ling, and orange roughy) to climate change is a significant barrier to designing and implementing adaptation strategies (Hurst et al. 2009; Law et al. 2018).

Ocean surface water has also acidified as anthropogenic CO_2 emissions have increased globally and been absorbed by the oceans (Law et al. 2018; MfE & Stats NZ 2019). Data reported by the Ministry for the Environment and Statistics NZ (2019) indicate sub-Antarctic waters off the coast of Otago have become 7% more acidic over the past 20 years. This trend is projected to increase this century, modifying the frequency, magnitude, and duration of harmful pH conditions throughout many marine areas of Aotearoa-NZ and making survival harder for organisms that rely on calcification, such as calcified algae, corals, molluscs, as well as some species such as starfish and sea urchins (Kroeker et al. 2013; Law et al. 2018). As many of these species hold significant social-cultural value for different whānau/hapū/iwi, any risks to their health are expected, in turn, to impact the health and well-being of Māori (King et al. 2010; DOC 2020). Further, some Māori have significant business interests in green-lipped mussel aquaculture and these investments appear vulnerable to ocean acidification and warming water temperatures (Law et al. 2018).[7]

Climate-change-induced sea-level rise in the coming decades is expected to permanently inundate some low-lying coastal areas such as harbours, estuaries, and tidal marshes. In addition, the greater reach of tides and storm surges is expected to increase the frequency, depth, and duration of coastal flooding. These gradual and abrupt changes are expected to modify the character of coastal ecosystems and alter the relationships within and between the different lifeforms that rely on them (e.g. pipi, clams, and other aquatic species that use these habitats as nurseries or during particular life stages). Potential loss of coastal-marine habitat and biodiversity raises deep concerns about the distribution and survival of cultural keystone species on which many Māori rely for food resources, cultural practice, and identity (Kitson 2006; King et al. 2010; Stephenson 2012). However, the response of these ecosystems to climate change will depend on the speed with which changes occur, and the ability of such systems and the biotic communities they support to respond and adapt to keep pace (Renwick et al. 2016).

A warmer climate and more extreme flood events can also result in cascading impacts for coastal-marine ecosystems. For example, in March 2019 floodwaters associated with the passage of Cyclone Trevor on the west coast of the South Island exposed a disused landfill and, subsequently, some 135,000 kg of waste washed downstream to the Tasman Sea (Westland District Council 2019). More waste continues to be released, and there is

[7] Incidentally, the marine heatwave of 2017/18 across the Aotearoa-NZ region led to significant mortality of salmon aquaculture stocks in the Marlborough Sounds (Salinger et al. 2019). While Māori investment in salmon aquaculture is low, it is likely that any interests in this industry will be challenged by projected warming temperatures. Such operations may be forced to shift their operations to cooler southern latitudes. Alternatively, onshore aquaculture may represent new business and employment opportunities for Māori (Te Puni Kōkiri and NIWA 2009).

growing evidence that many other landfills in Aotearoa-NZ are vulnerable to the effects of extreme weather and climate-induced sea-level rise. Proactive remediation of problematic landfills will be required (with financial support from local and central government) to prevent plastic and other potentially toxic waste from polluting coastal-marine ecosystems. Such degradation poses significant risks to Māori social, cultural, spiritual, and economic well-being.

Looking ahead, there is a need to monitor the variability and rate of change in marine temperature, pH, and carbonate systems around Aotearoa-NZ to understand the ecosystem effects of acidification on marine primary production, food quality, key habitat availability, and biotic communities. There is also a need to improve understanding of environmental-change cascades in terms of causal relationships, feedbacks, and the effects of resource use, habitat loss and invasive species on biodiversity and taonga species in coastal-marine ecosystems. Enhancing understanding of the links between these interacting and cascading drivers will help predict and manage adverse impacts of climate change on coastal marine ecosystems, and provide a basis for reducing, preventing, and ameliorating damage. Other priorities include actively monitoring, removing, and controlling the spread of invasive plants and marine animals, and reducing sediment and nutrient runoff to lessen the risks of harm to aquatic animals and other coastal-marine organisms. The complexity of these interacting drivers and agents emphasises the need for plural approaches and methods that draw not only on scientific knowledge but also on mātauranga Māori and different social and cultural values to inform ecological baselines, assessments, and well-being.

Table 2. He arotake tūraru – He kura taiao, living treasures

Sector	Group	Interests	Risk		Adaptation strategies
Terrestrial Ecosystems	Iwi, hapū, whānau, trusts, incorporations, and pan-Māori	Indigenous flora and fauna	Now	Minor	• Implement monitoring practices that provide for the early detection of climate-induced invasive plants, animals, and insects • Support the control and manual removal of climate-induced invasive species • Improve understanding of biodiversity-climate linkages, with a view to prioritising activities to restore degraded ecosystems and habitats • Develop new approaches to ecosystem utilisation, protection, and management, that draw upon science and Mātauranga Māori
			2050	Moderate	
			2100	Major	
Terrestrial Ecosystems	Iwi, hapū, whānau, trusts, incorporations, and pan-Māori	Managed flora and fauna	Now	Moderate	• Utilise more water-wise irrigation technologies • Grow crops that are better adapted to warmer, drier summers • Implement monitoring practices that provide for the early detection of climate-induced invasive plants, animals, and insects • Explore the suitability of tribal lands for reforestation/afforestation to harness the multiple functions of forests, from supporting biodiversity and ecosystem services to carbon sequestration and controlling erosion
			2050	Moderate	
			2100	Major	
Freshwater Ecosystems	Iwi, hapū, whānau and pan-Māori	Rivers and streams	Now	Moderate	• Enhance riverbank vegetation to slow erosion and provide shade and cool water for freshwater species • Assist the migration of vulnerable animal species to suitable habitats • Implement monitoring practices that provide for the early detection and removal of climate-induced invasive plants, aquatic animals, and insects • Improve understanding of freshwater species vulnerability to climate change, with a view to prioritising activities to restore degraded ecosystems and habitats
			2050	Moderate	
			2100	Major	
Freshwater Ecosystems	Iwi, hapū, whānau, and pan-Māori	Lakes and wetlands	Now	Minor	• Enhance riverbank vegetation to slow erosion and provide shade and cool water for freshwater species • Assist the migration of vulnerable animal species to suitable habitats • Implement monitoring practices that provide for the early detection and removal of climate-induced invasive plants, aquatic animals, and insects • Improve understanding of freshwater species vulnerability to climate change, with a view to prioritising activities to restore degraded ecosystems and habitats
			2050	Moderate	
			2100	Major	

Sector	Group	Interests	Risk		Adaptation strategies
Coastal-Marine Ecosystems	Iwi, hapū, whānau and pan-Māori	Coastal lagoons estuaries and harbours	Now	Minor	• Monitor the variability and rate of change in water temperature, pH, and carbonate systems at different sites • Improve understanding of the effects of acidification on marine primary production, food quality, habitat availability, and aquatic species • Develop new approaches to ecosystem utilisation, protection, and management, that draw upon science and Mātauranga Māori • Monitor, remove, and control the spread of climate-induced invasive species as well as reduce sediment and nutrient runoff to lessen the risks of harm to coastal-marine organisms
			2050	Moderate	
			2100	Major	
Coastal-Marine Ecosystems	Iwi, hapū, whānau, and pan-Māori	Inshore and open ocean	Now	Minor	• Monitor the variability and rate of change in marine temperature, pH, and carbonate systems at different sites around Aotearoa-NZ • Improve understanding of ecosystem effects of acidification on marine primary production, food quality, habitat availability, and aquatic species • Develop new approaches to ecosystem utilisation, protection, and management, that draw upon science and Mātauranga Māori • Monitor, remove, and control the spread of climate-induced invasive species as well as reduce sediment and nutrient runoff to lessen the risks of harm to coastal-marine organisms
			2050	Moderate	
			2100	Major	

4 Kaupapa Māori Risk Assessment: Whakatipu Rawa – Māori Economy

This section reviews how climate change is likely to affect the Māori Economy, which includes (or is defined as) Māori post-settlement governance entities, Māori land trusts and incorporations, and Māori self-employed businesses engaged in trade and exchange. We begin by outlining the main economic industries in which Māori capital[8], enterprise[9], and employment[10] are clustered, and then provide a more in-depth review at the industry level to highlight where exposure and vulnerability are most likely. Thereafter, we identify key climate change risks and consider potential response and adaptation strategies. It is important to note that, while climate change and its environmental and economic impacts have been studied at a general level in Aotearoa-NZ, in-depth analyses for Māori enterprise and industries such as agriculture, forestry, and fishing are lacking. Consequently, we have drawn on national and international research trends and patterns where specific analyses and details are not available. A risk assessment for this domain is provided in Table 3 at the end of this section.

The Māori asset base is reported to be worth $68 billion (Reserve Bank of NZ and BERL 2021). Some 57% of assets are held in small- to medium-sized enterprises, with 31% collectively held by post-settlement governance entities, Māori land trusts and incorporations, and 12% in businesses of self-employed Māori (Reserve Bank of NZ and BERL 2021). Some 32% of all Māori businesses are classified in the service industry, which includes the production and distribution of goods as well as rental, hiring and real estate services (see Figure 7). The next-biggest industry is natural resources, which includes agriculture, horticulture, farming, fishing, and forestry. Most of the remaining Māori businesses are in the manufacturing industry. Together, the natural resource and manufacturing industries account for 68% of all Māori-owned businesses (Reserve Bank of NZ and BERL 2021).

[8] Māori capital refers to any Māori investment, be it iwi, incorporation, trust, hapū or private.

[9] Māori enterprise refers to any Māori owned businesses, be they collectively or privately owned.

[10] Māori employment refers to the sectors in which Māori are employed

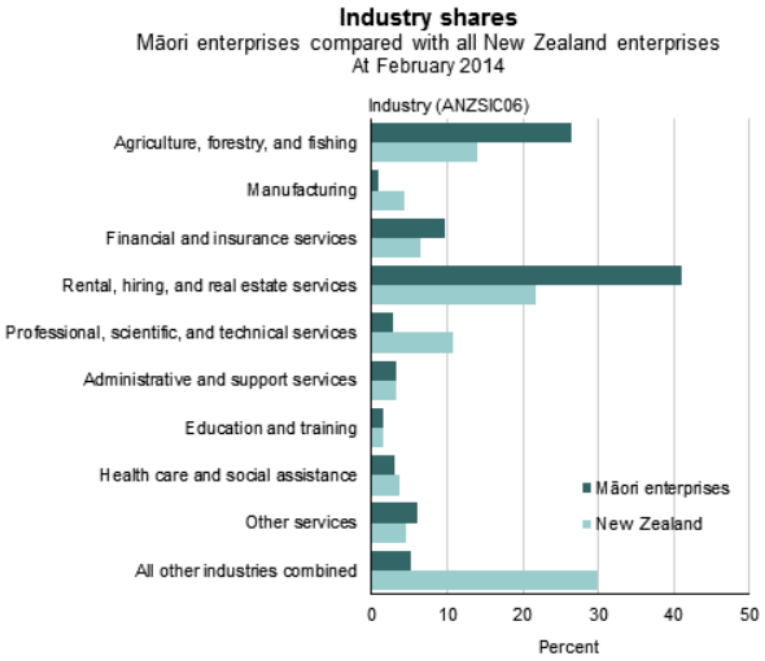

Figure 7. Māori enterprises compared with all New Zealand enterprises. Source: Statistics New Zealand (2014).

Commercial Fisheries

Māori collectively own 33% of all fisheries quota by volume and 20% by value ($652 million) (Rout et al. 2018; Reid et al. 2019). A recent report by Reid et al. (2019) mapped the Māori marine economy and found that most activity in the industry is undertaken by iwi settlement entities, which have a share in Moana New Zealand. Furthermore, 100% of these entities manage their own quota, through Annual Catch Entitlements (ACE) trading, while 61% of the Māori businesses overall are actively acquiring more quota. This indicates a strong and growing Māori interest in fisheries. In addition, analysis shows that 45% of iwi businesses have entered joint-venture partnerships with other iwi and non-Māori fishing companies to fish their quota. Some 8% are fishing their own quota, 10% are processing their own fish, 10% are self-branding, and 8% are exporting, of which 90% are exporting under their own brand.

Nearly two-thirds of Māori fisheries assets by value ($411 million) are concentrated in four species: kōura (rock lobster), pāua, snapper, and hoki (Reid et al. 2019; Rout et al. 2018). Kōura and pāua are likely to face substantial risks from climate change as they are adapted to cooler waters and sensitive to changes in temperatures (Dunn et al. 2009; Price 2016). Ocean acidification could add to the risk as lower pH levels threaten kōura and paua development, particularly dissolution of shell surfaces (Boyd & Law 2011). Inshore fisheries like kōura and pāua account for 44% of the quota invested in by Māori ($289 million), and consequently any risks to production from climate change are a significant concern for Māori.

Research indicates that increasing water temperatures and ocean acidification present both opportunities and threats to snapper and hoki fisheries (Parsons et al. 2014). Changing ocean temperatures may result in a southward shift of some tropical species

and present new opportunities for the industry in Aotearoa-NZ. However, a lack of information about the vulnerability of other wild fish stocks (e.g. scampi, tarakihi, gurnard, ling, and orange roughy) to climate change is a significant barrier to designing and implementing any adaptation strategies (Hurst et al. 2009; Law et al. 2018). Further analysis is required to identify possible new species and understand their potential value to the Māori economy.

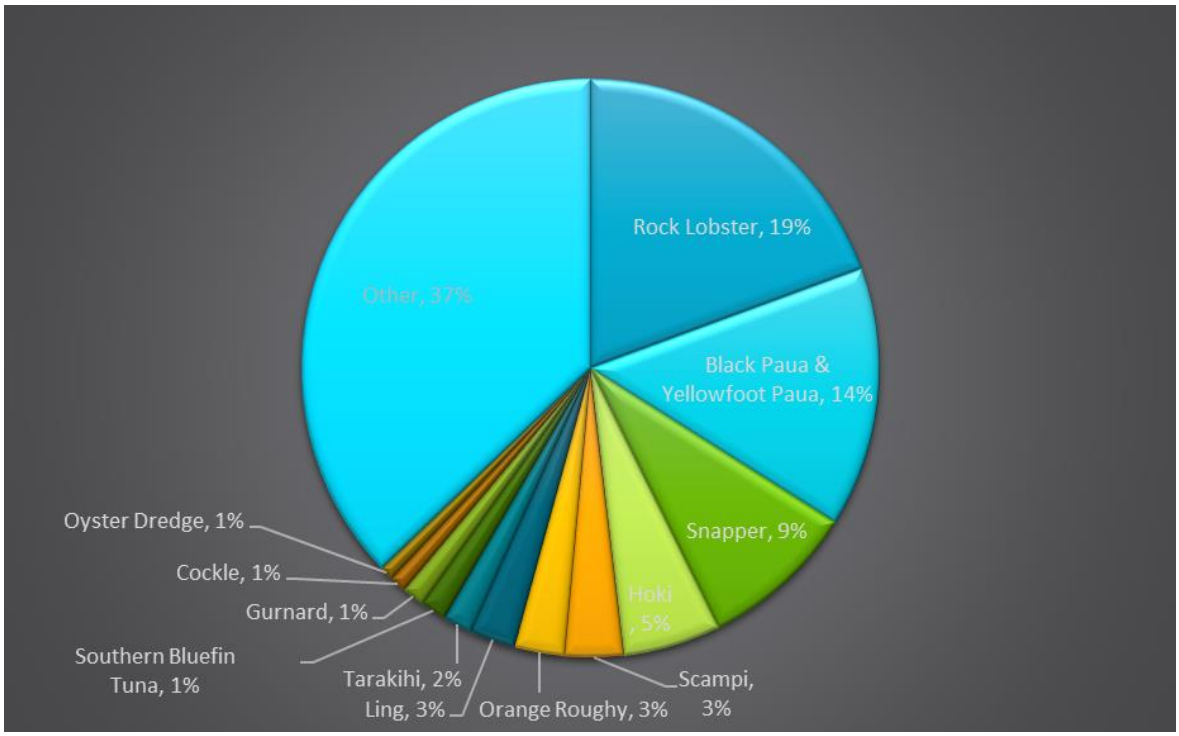

Figure 8. Māori ownership interests in wild fisheries by percentage of investment value.

Overall, Māori have increased investment in high-value species like snapper, pāua and kōura, which has created significant economic benefits. However, these species appear highly vulnerable to climate change, exposing the Māori fishing industry to significant risk. Better understanding of this risk is required to enable planning for the sustainable management of high-value species. Shifting investment into resilient species, aquaculture, or other alternatives will likely be required.

Marine Mammal Tourism

Māori hold investments in whale- and dolphin-watching tourism ventures in the North and South Islands. For example, Whale Watch Kaikoura is 100% Māori owned and serves around 80,000 customers a year (DOC 2019). In a 1999 report, Dr Mark Orams of Massey University estimated that one humpback whale, returning every year to breed in Tongan waters, would generate US$1 million in tourism revenue during its 50-year lifetime (DOC 2019). The main impacts of climate change on marine mammal populations are likely to be losses and/or shifts in food sources and exposure to new pathogens (Grose et al. 2020). While marine mammals can adapt to differing water temperatures, some species may have to move their habitats to find prey, and may – in the worst-case scenarios – struggle to build up the energy reserves needed to migrate (Grose et al. 2020). The marine mammal

tourism industry relies on the relatively consistent appearance of whales and dolphins, and climate-change-induced disruptions therefore pose significant risks to Māori investment and interests in this industry. Very little information is available on the likely changes to key marine mammal populations in different locations in New Zealand.

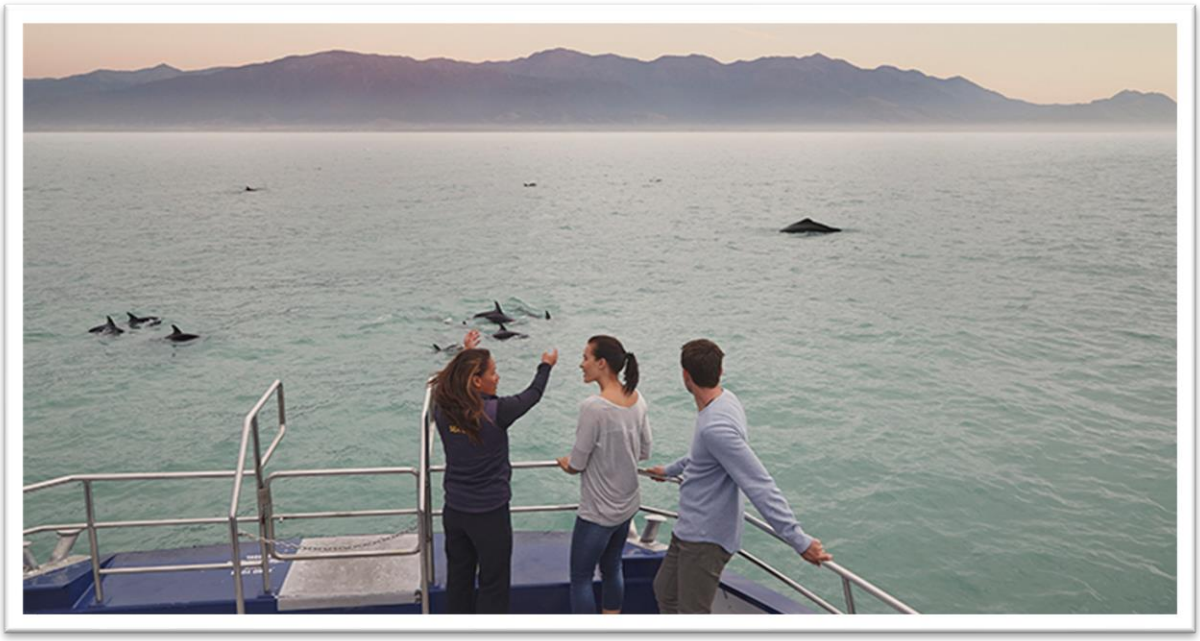

Figure 9. Whale Watch Kaikoura. Image: Sustainable Seas NSC.

Aquaculture

The two key aquaculture species in Aotearoa-NZ are green-lipped mussels and salmon. Māori investments in these species are currently low, but several iwi have been exploring investment in green-lipped mussels. Green-lipped mussels appear vulnerable to warming waters and ocean acidification, both of which impact development and growth rates (Petes et al. 2007; Law et al. 2018). Sanford have already closed their Christchurch processing plant because of the effects of climate change on mussel populations (Lake et al., 2018). Increasing acidity in oceans has also been implicated in preventing mussels from attaching themselves to rocks and other substrates (Newcomb et al. 2019). Such changes represent risks not only for their lifecycle but also for production and any future investments by Māori in this industry. It is also known that salmon are sensitive to water temperature changes across most stages of their lifecycle. Temperature shifts beyond threshold ranges can either inhibit critical lifecycle phases or cause mortality (Richter & Kolmes, 2005). As a result, salmon farming may be forced to move further south to cooler waters, and/or offshore, creating both barriers and new opportunities for Māori investment in this industry (McDowall, 1992; King et al. 2010). Further analysis is required to quantify the specific impacts on the Māori economy. Valuation and location data on specific Māori investments are required for this analysis.

Exotic Plantation Forestry

Production forestry in Aotearoa-NZ is made up of two key species: 89% is *Pinus radiata* and 5% is Douglas fir. The remainder comprises a variety of species, such as eucalypts. Māori have invested heavily in the forestry industry. Capital investment on Māori farms increased by some 68% between 2006 and 2016 (from 65,864 ha to 110,393 ha) (MfE & Stats NZ, 2018). At present there are confounding data on how the production forestry industry in Aotearoa-NZ will be impacted by climate change. Increases in air temperature are likely to have a predominantly positive effect on plantation growth, particularly in cooler regions where the length of the growing season is projected to increase (SCION, 2012; Reisinger at al. 2014). However, productivity in northern and eastern parts of the country, where Māori hold significant investments, is likely to be adversely impacted by projected warming temperatures and reductions in rainfall (although uncertainties remain about the stimulating influence on plant growth of more atmospheric CO_2) (Kirschbaum et al., 2012). Further analysis is required to fully understand the spatial extent of specific Māori investments in exotic forestry, including Māori employment in the wood processing industry.

Projections for drier conditions in the north and east of the country also point to increasing fire risks for managed forests across these regions (Pearce et al. 2005, 2011; Reisinger et al. 2014; Renwick et al. 2016). Reducing such risks will require careful planning and management. Steps might include cutting fire breaks, creating better access to water sources, and planting natives between pine forests. More frequent severe weather events also pose a high risk to plantations, especially during early forest establishment when land is most exposed to high intensity rainfall (SCION, 2012; Reisinger et al. 2014). In addition, an increase in the prevalence of invasive pests and diseases can affect monocultural forest species such as *Pinus radiata* and Douglas fir. While relatively little is known about the Douglas fir in Aotearoa-NZ, it is likely that severe pathogens such as the pine disease Dothistroma blight will increase their spread due to warmer air temperatures (SCION, 2012). Given that most Māori forestry land is located on the east coast, adverse impacts are likely to disproportionately affect Māori investment (King et al. 2010). Further analysis is required to understand the value, extent and opportunities for Māori investment in indigenous forestry under a changing climate.

Agriculture

Changing climatic conditions are expected to present both risks and opportunities for Māori interests and investment in agriculture across Aotearoa-NZ. Māori hold significant investments in dairy, as well as beef and lamb farming, and feature highly on enterprise and employment indices. Nationally, Māori represent 10% of dairy production and 30% of beef and lamb production (Reserve Bank of NZ and Berl 2021). In 2016, 450,593 effective hectares (ha) of Māori land were used for agricultural production, with nearly half that total (217,933 ha) in grassland or pasture focused on dairy or beef and lamb production (MfE & Statistics New Zealand 2018). Overall, the dairy industry is expected to benefit from increased production under climate change due to increasing rainfall and CO_2 levels, which will stimulate photosynthesis (MfE 2001). However, there are likely to be seasonal and regional differences. Drought is also likely to affect summer yields of pasture in areas such as the Hawke's Bay, Wairarapa, the eastern South Island, and Central Otago (Lake et

al. 2018), altering the seasonal timing of production (MPI 2019). Increasing temperatures and droughts will likely make dairy cattle welfare more important (MfE 2018). Further analysis is required to better understand the risks and potential benefits facing Māori involvement in the dairy farming sector.

Meanwhile, sheep and beef farms cover more diverse land types and climates across Aotearoa-NZ than dairy, making assessments about this sector difficult. Increasing atmospheric CO_2 levels are nonetheless expected to have beneficial effects on pasture production over coming decades, although these benefits are most likely to be in cooler, wetter areas such as the southern South Island, while warmer and drier areas are more likely to experience smaller or negligible increases (MfE 2001). Drought also represents a significant existing risk for sheep and beef farmers in eastern Aotearoa-NZ and changing rainfall and hydrological regimes are likely to exacerbate these risks (MfE 2001). Projected increases in temperature also pose serious risks for livestock directly through heat stress, and indirectly through potential increases in existing parasites like facial eczema and/or the introduction of new parasites (Lake et al. 2018). Due to the physical nature and location of many Māori farms in eastern and northern regions of the country, further analysis is required to better understand the comparative risks and potential benefits of changing climate conditions on Māori sheep and beef farming investments.

Horticulture

Māori investment in horticulture is significant and increased some 65% between 2006 and 2016 (from 1,616 ha to 2,668 ha) (MfE & Statistics New Zealand 2018). The majority of investment is in kiwifruit in the eastern Bay of Plenty, where Māori own around 10% ($220 million) of the total value of this industry (Reserve Bank of NZ and BERL 2021). Sustained periods of low or no precipitation projected for this region are expected to make surface water supplies scarce, affecting groundwater recharge and potentially affecting harvest and crop yields (Tait et al. 2018). Storm events and sustained periods of heavy rain, coupled with sea-level rise, could also reduce the ability of drainage systems and other infrastructure to handle flood events on near-coastal agricultural lands (Reisinger et al. 2014). These projected impacts represent significant risks for Māori investment in the Bay of Plenty region (MfE 2001). However, projected changes to temperature and rainfall regimes in other regions, particularly the southern North Island, Canterbury, and Central Otago, may present new opportunities for kiwifruit production (Tait et al. 2018). However, such opportunities may have little benefit for the majority of Māori landowners, as most Māori freehold land is in the upper North Island. Investment outside traditional areas may be a necessary adaptation strategy. Further analysis is required to better understand other horticultural opportunities available to Māori growers under a changing climate.

Property

Māori have significant commercial property investments across the country. Three iwi, Ngāi Tahu, Ngāti Whātua o Ōrākei, and Waikato-Tainui, own the greatest share. The majority of Ngāi Tahu-owned commercial properties are in Christchurch, with other properties distributed elsewhere in the South Island. Ngāti Whātua o Ōrākei and Waikato-Tainui own properties in Auckland and Hamilton (and the wider Waikato region), respectively. These investments face a range of climate-related risks. Much of Christchurch

is low-lying and therefore exposed to sea-level rise impacts over the long term, especially on the eastern side of the city. However, risks to the built environment are considered to be relatively low in this region (MfE 2018a). Ngāi Tahu's assets outside Christchurch are mostly inland and not at risk from sea level rise. A recent report on climate change impacts in Auckland notes: "Sea level rise could put infrastructure and ecosystems at risk while flooding poses direct and indirect risks to people, infrastructure, and services" (Auckland Council 2019). Auckland is at particular risk as large areas are low-lying, with many inlets, harbours, and waterways. Auckland Council estimates that roughly a third of buildings in the city are at risk of flooding, which is identified as the most common natural hazard in the area (Auckland Council 2019). Further spatial analysis at a regional level is required to understand the risk to Māori property investments. Hamilton, due to its inland position, is comparatively resilient to climate change impacts (Storey & Noy 2017; Storey et al. 2017) with a lower risk of flooding and slow-onset sea-level rise. A potential strategy is to transition Māori-owned commercial property away from coastal and riverine locations where flooding and inundation are most likely to occur. This will lessen risk and protect returns for future generations. Māori businesses looking at building or purchasing commercial or residential property (or even to understand the risks on their existing properties) should work closely with local and central government agencies, research institutes and universities to establish the risks in specific locations, before proceeding.

Employment

Climate change impacts, risks and mitigation measures may see either a decline or growth in employment opportunities for Māori within different industries (MBIE 2019a). Adverse weather events and changing climatic conditions are likely to increase demand for workers involved in the building industry and infrastructure. Sea-level rise impacts and risks will also necessitate either remediation or reconstruction, especially of coastal areas and floodplains, creating extra demand for semi-skilled and skilled professionals in the construction industry. Comparatively high numbers of Māori are employed in the construction industry (MBIE, 2018) (See Figure 8), which suggests that Māori working in this sector have a high degree of job security. Similarly, comparatively high numbers of Māori are employed in the health sector. Climate change risks to human health, including direct impacts from heatwaves, secondary impacts from infectious-disease vectors, and tertiary impacts upon mental health, will likely demand that the public health sector develops and strengthens its workforce (NZCPHM 2013). This suggests that employment for Māori across this diverse sector will be relatively secure. In contrast, international studies have shown that rising temperatures decrease manufacturing efficiency and profitability, resulting in the need for low-to-medium skilled workers to retrain or upskill (Zhang et al. 2018). Such patterns may pose some risks for Māori involved in the manufacturing industry in Aotearoa-NZ (MBIE 2018). Much greater analysis is required to unravel the climate change risks and opportunities facing Māori employment across different industries.

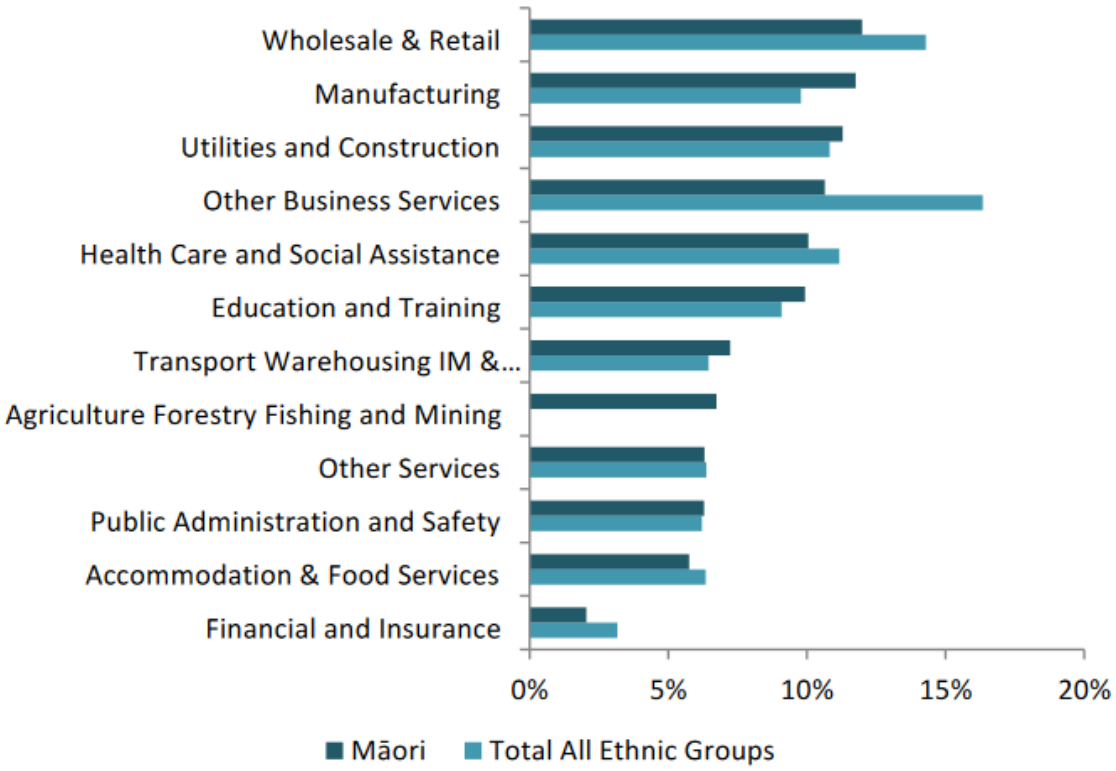

Figure 10. Proportion of Māori employed in industries, June 2019. Source: Ministry of Business Innovation and Enterprise (MBIE) 2019b.

Table 3. He arotake tūraru – Whakatipu Rawa, Māori Enterprise

Sector	Group	Interests	Risk		Adaptation strategies
Commercial Fishery	Iwi, hapū, trusts and incorporations	Kōura, pāua, snapper, gurnard, hoki, scampi, tarakihi, ling, and orange roughy	Now	*Minor*	• Transition quota over time for kōura, pāua, hoki • Investigate management areas for snapper to determine individual risk/opportunity • Retain quota for gurnard and potentially purchase more
			2050	*Major*	
			2100	*Major*	
Aquaculture	Iwi, hapū, trusts and incorporations	Green-lipped mussels, salmon, and multi-trophic	Now	Minor	• Sell quota for green-lipped mussels • Relocate salmon farms offshore or further south • Enter sector for multi-trophic aquaculture
			2050	Moderate	
			2100	Major	
Marine Mammal Tourism	Iwi, hapū, trusts and incorporations	Marine mammal watching	Now	Minor	• Transition to other investments, invest in alternative businesses that utilise the same infrastructure and equipment
			2050	Moderate	
			2100	Major	
Exotic Plantation Forestry	Iwi, hapū, trusts and incorporations	*Pinus radiata* and Douglas fir	Now	Moderate	• Examine the risk potential for northern North Island plantations • Evaluate the opportunity for southern plantations
			2050	Moderate	
			2100	Major	
Agriculture – Beef and Lamb	Iwi, hapū, trusts and incorporations	Farms	Now	Moderate	• Invest in climate-resilient breeds and pasture species (e.g. drought- and erosion-tolerant) • Invest in water storage particularly for drought-prone areas • Invest in a diverse landscapes or agroforestry approaches for agribusiness
			2050	Moderate	
			2100	Major	
Agriculture – Dairy	Iwi, hapū, trusts and incorporations	Farms	Now	Moderate	• Invest in climate-resilient breeds and pasture species (e.g. drought-tolerant) • Invest in water storage particularly for drought-prone areas • Invest in a diverse landscapes or agroforestry approaches for agribusiness
			2050	Moderate	
			2100	Major	

Sector	Group	Interests	Risk		Adaptation strategies
Horticulture	Iwi, hapū, trusts and incorporations	Kiwifruit, pip fruit and viticulture	Now	Moderate	• Kiwifruit – move operations or transition to Zespri gold or another horticultural species • Invest in water storage particularly for drought prone areas • Invest in apple breeds with climate resilient characteristics • Viticulture – migrate vineyards southward or to higher altitudes
			2050	Moderate	
			2100	Major	
Property	Iwi and hapū	Commercial	Now	Moderate	• Develop adaptation strategies for commercial property in low-lying coastal areas like Auckland and Dunedin • Work closely with local and central government agencies, research institutes and universities to understand the risks in specific locations
			2050	Moderate	
			2100	Major	
Employment	Iwi and hapū	Employers, employees, and unions	Now	Minor	• Māori working in the food and beverage subsector may need to assess the risks of their position, particularly those working in horticulture • Develop Māori capability through upskilling and provide approaches to transition to other sectors • Help transition the labour force towards public health areas most impacted by climate change, including mental health, food insecurity and infectious diseases
			2050	Moderate	
			2100	Major	

5 Kaupapa Māori Risk Assessment: He Oranga Tāngata – Healthy People

There is consensus across the body of scientific literature on the harmful impacts of climate change on human health (Costello et al. 2009; McMichael et al. 2012; Watts et al. 2019) and especially on indigenous social and cultural well-being (Neef et al. 2018; Ford et al. 2020). Direct impacts include illness, injury, and in extreme cases death. Indirect impacts mediated by complex interactions between social, environmental, and economic factors also pose significant risks for human health (Hallegatte et al. 2015; Hallegatte & Rozenberg 2017). As warming of the climate system continues, adverse health impacts are expected to be more severe and borne disproportionately by indigenous people and groups already suffering health inequities (Jones et al. 2014; Royal Society of New Zealand/Te Apārangi 2017). While there is a limited pool of public health-related climate change research in Aotearoa-NZ, there is emerging evidence about the threat of changing climatic conditions on Māori well-being and health, as well as examples of Māori-led initiatives to address these risks (Jones et al. 2014). This section considers the status of Māori health in Aotearoa-NZ, discusses the projected impacts of climate change on Māori health and identity, and considers these within the context of institutions that govern Māori health responses. The section concludes with suggested strategies and options for strengthening Māori public health and resilience in response to the challenges from climate change. A risk assessment (Table 4) is given for this domain at the end of this section.

Relationships between Climate Change and Māori Health

While climate action presents many opportunities to improve health and reduce inequities, there is also the potential for climate mitigation and adaptation policies to reinforce existing inequities and create new barriers and obstacles to human-environment health (Jones et al. 2014). A range of factors, with roots in historic and ongoing forms of political marginalisation, underlie the disproportionate risks facing Māori public health (Harris et al. 2012; Cormack et al. 2018). These factors include existing Māori health disparities (Ministry of Health 2019b); poorer access to and quality of health care (Brown 2018; Graham & Masters-Awatere 2020); socio-economic deprivation (Jones et al. 2014; Jones 2019); and political marginalisation (Harris et al. 2012; Lewis et al. 2020). Fundamentally, Māori views of health are holistic and recognise the relational and kin-centric connection between people and ecosystems (Panelli & Tipa 2007; Harmsworth & Awatere 2013). However, Eurocentric views, based on universalistic approaches, have been prioritised into public health and climate change policy (Lewis et al. 2020).

An increasing number of declarations and legislative frameworks could be utilised to support Māori worldviews and holistic framings of well-being to create climate-resilient futures. The United Nations Declaration on the Rights of Indigenous Peoples maintains that "Indigenous Peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals, and minerals" (Article 24, p. 9, UN General Assembly 2007). This simple right, alone, links to other inalienable rights of indigenous peoples such as the right to see their lands, languages, and cultures flourish (Articles 4, 13, 25, and 29); all of which underscore the

necessity of holistic responses to climate change. In Aotearoa-NZ, the health sector could be a powerful actor by working with Māori to promote ground-up holistic approaches to Māori resilience and well-being in response to climate change. However, the sector currently lies at the peripheries of intersectoral action.[11] Additionally, there are significant gaps in information about the impacts of climate change on health, including Māori health (Howden-Chapman et al. 2010; MfE 2017). Research in other parts of the world into the inequitable impacts of climate change on distinct populations (Williams et al. 2018; Nursey-Bray et al. 2020), suggests that, unless there are urgent and substantial pro-equity policy changes, both within and beyond the health and disability sector, climate change will exacerbate health inequities for Māori (Bennett & King 2018; Hickey 2020).

Intensification of Māori health Inequities due to Climate Change

Māori experience markedly poorer outcomes in relation to many important health conditions in Aotearoa-NZ and these may be exacerbated by changing climate conditions. For example, hospitalisation rates for cardiovascular disease in 2012-2014 were more than twice as high for Māori as for non-Māori (Ministry of Health 2018a). Māori men also experience higher rates of coronary heart disease case mortality, and have the worst cardiovascular treatment outcomes of all population groups (Jeremy et al. 2010; Ministry of Health 2018a; Tobias et al. 2009). Climate-change-induced extreme heatwaves are likely to increase these risks for Māori (Peters & Schneider 2021; Watts et al. 2019). Addressing disparities in cardiovascular outcomes will require formulating and delivering models of care that better cater to the needs of vulnerable Māori populations (Curtis et al. 2010; Lee & North 2013; Miner-Williams 2017).

Chronic kidney disease (CKD) is also recognised as a health problem (Adeera et al. 2017), and yet is not included on most priority lists of non-communicable diseases (NCDs). Māori and Pacific peoples have a higher incidence of CKD and end-stage renal failure than any other ethnic group in Aotearoa NZ (Collins 2010). Stress on the kidneys is understood to increase with rising temperatures, and thereby projected increases in the intensity and frequency of heat-waves are expected to put those who are employed in outdoor occupations at a higher risk of heat-related morbidity and mortality (Li et al. 2021). Similar risks also apply to the young, elderly and those with pre-existing health conditions (Schwartz et al. 2004). Māori and others with medical conditions whose work is physically demanding (such as manual workers and outdoor labourers) are likely to face increasing risks detrimental to their health (Denison et al. 2018; Groot et al. 2017). With close to 20% of Māori employed in the manufacturing and construction industries, climate-change-induced heatwaves pose a significant risk to Māori health.

[11] For example, the Ministry for Environment's (2020) recent summary of climate policy for iwi/Māori provides a high-level summary of policy across government that includes: Ministry of Foreign Affairs and Trade, Ministry of Transport, Ministry for Primary Industry, Ministry for Environment, Ministry of Business, Innovation and Employment and Department of Conservation. The same summary also notes however, that not all Government policy work is reflected here and that, for example, the Ministry of Health is working on the Environmental Health Action Plan.

Diabetes is at unprecedented levels in many countries and is disproportionately affecting Māori in Aotearoa NZ. Age-standardised diabetes prevalence is 1.6-2.4 times higher for Māori than for those of European ethnicity (Ministry of Health 2020a; 2020b). This is associated with a substantial burden of diabetes-related complications, with increased rates of cardiac, renal and eye conditions and amputations (Ministry of Health 2020b), which result in significant avoidable mortality for Māori (Walsh & Grey 2019). Temperature changes can increase susceptibility to diabetes onset, and impose adverse effects, such as increased incidence of dehydration, hospitalisation, and mortality, on those already diagnosed with diabetes (Cuschieri & Agius 2020). During heatwaves, diabetics are more likely to need hospital treatment (Xu et al. 2019; Green et al. 2010). Those with diabetes mellitus are more prone than non-diabetic individuals to dehydration and heatstroke (McGeehin & Mirabelli 2001). This has serious implications for Māori hospitalisations and mortality.

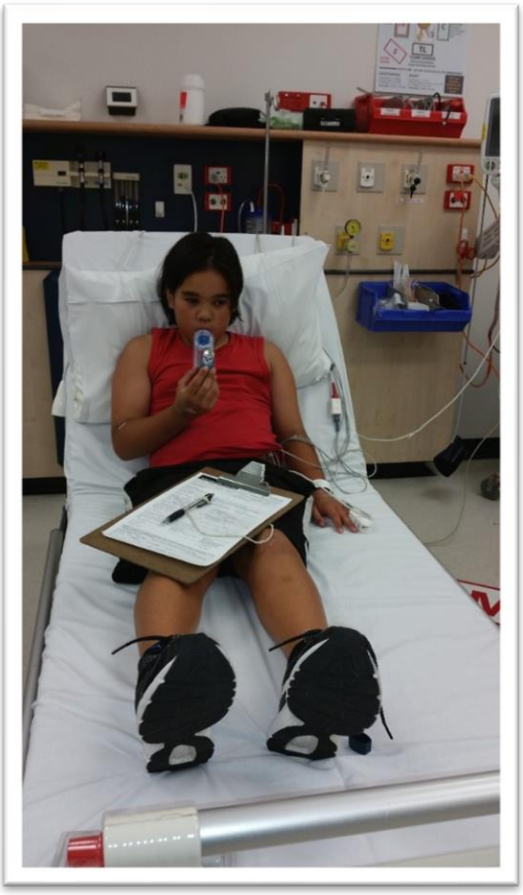

Figure 11. Hospital Admission. Image: B Masters-Awatere.

Māori have one of the highest rates of medicated asthma (Environmental Health Indicators 2020) and are almost twice as likely as non-Māori to be hospitalised for asthma (Ministry of Health 2018b). According to the World Allergy Organization (WAO) climate-change-related health impacts will likely include increased frequency of acute cardio-respiratory events associated with higher concentrations of ground level ozone as well as changes in the frequency of respiratory diseases due to altered distributions of allergens (pollens, moulds, and mites) (D'Amato et al. 2015). Given that asthma hospitalisations for Māori are

strongly linked to environmental conditions (Graham & Masters-Awatere 2019; Jaakkola et al. 2011) these projected impacts will not only affect Māori who already suffer from asthma, but potentially increase the incidence and prevalence among Māori to allergic respiratory conditions.

Climate change is also expected to increase the risk of exposure to vector-borne diseases (e.g. mosquito- and tick-borne diseases), particularly for vulnerable populations like Māori (Royal Society of New Zealand/Te Apārangi 2017). Vector-borne diseases pose new health risks for whānau, especially when attending events like tangihanga, hui and festivals at marae that are close to mosquito habitats. Toxic algae blooms are also likely to occur more frequently during warmer weather and prolonged periods of dryness, degrading freshwater systems and impacting the availability of taonga species (e.g. pāua, kina and kōura) for marae-based events. At the same time, marae may have to manage potential risks to potable water supplies, particularly where water is sourced from unreticulated and unfiltered systems such as tank water and/or groundwater wells in intensively farmed areas (Royal Society of New Zealand/Te Apārangi 2017). The sensitivity of Māori health to climate change risks, poses a serious issue for the Aotearoa-NZ health sector.

Climate Change Impacts on Māori Identity

Despite the direct and indirect challenges brought on by climate change, Māori continue to promote understandings of health which emphasise an individual and collective continuum that crosses generations. For Māori, well-being is holistic, incorporating spiritual, intellectual, physical, social, and emotional dimensions and, importantly, relationships with the natural environment (Robertson & Awatere 2007; Jones et al. 2014). Intergenerational attachments to ancestral lands are intrinsic and important symbolically, emotionally, and spiritually. They are articulated by examples of iwi/hapū identity and belonging, nourishing a sense of continuity between generations, and reinforcing spiritual well-being in the form of whakapapa, sacred maunga [mountain] and ancestral rivers (Te Awekotuku & Nikora 2003; Panelli & Tipa 2007; Harmsworth & Awatere 2013). Also closely intertwined with psychological and spiritual well-being (as well as physical health) are the practical ways in which ancestral lands, wetlands, and waterways support customary resources and strengthen practices such as mahinga kai [food gathering and cultivation areas], rongoā rākau [Māori healing], including access to indigenous flora for plant medicines, and harvesting of harakeke [flax] and other materials used for practical, artistic, or ceremonial purposes. These ongoing relational links with whenua [land], and tūrangawaewae [family connections] are crucial to the cultural and psychological well-being of Māori and the transmission of mātauranga Māori (Institute of Environmental Science and Research 2009; Boulton et al. 2014; Reid et al. 2016). The link between people and ecosystems will be tested by a changing climate, which poses an additional challenge for maintaining Māori identity and practising ethics of care [manaakitanga] and intergenerational sustainability [kaitiakitanga].

Figure 12. Bug on a Kawakawa leaf. Source: B Masters-Awatere.

Institutional Health Systems

The right of whānau/hapū/iwi to be self-determining is fundamental to the Te Tiriti o Waitangi partnership between the Crown and Māori. The Resource Management Act (RMA) 1991 is an important regulatory pathway for enabling this partnership. The RMA is under the jurisdiction of local government and supports the development of hapū and iwi management plans. These focus on the aspirations of whānau/hapū/iwi, and, like Māori approaches to well-being, are holistic in their approach to health. Grounded in the mātauranga, language, and tikanga of distinct hapū and whānau, these plans form the basis of Māori resilience, and are a potential key means of Māori-led action on climate change. Bargh et al. (2014) argued that if such plans are to succeed in fostering sustainable tribal economies in times of climate change, whānau/hapū/iwi will need to participate and act immediately in a wide range of areas, including: addressing coastal erosion, flood control, native planting and water quality, tribal self-determination, genetic engineering, and understanding the critical relationship between Māori business and local ecosystems. However, recent research suggests that many whānau/hapū/iwi do not have the resources to adequately review and update such plans. For example, Ministry of Environment records indicate that just 23 plans have been successfully updated by iwi/hapū since 2015/16 (MfE 2019b), while a review of Bay of Plenty iwi/hapū management plans finds little specific mention of climate change in the vast majority of plans (Tauranga City Council 2021). Furthermore, while often strongly identifying cultural and environmental aspirations, hapū management plans are generally much weaker in their linkages to the public health sector – in part because jurisdiction falls under local government. Opportunities to strengthen critical climate change adaptation and mitigation strategies through linkages with the public health sector are needed.

The health sector has been slow to incorporate environmental health and climate change considerations into its policy and planning programmes. This is unsurprising, given the sector's predominant western bio-medical orientation, its budgetary pressures, and its

emphasis on illness and 'treatment' models (Ellison-Loschmann & Pearce 2006; Masters-Awatere et al. 2019). At the same time, there is a comparatively slim allocation of resourcing to 'upstream' prevention and health-promotion initiatives (HQSC 2019) that could be aligned with climate change adaptation and mitigation strategies and action. According to a recent 'stocktake' of the country's readiness to implement climate change adaptation strategies undertaken by the Climate Change Adaptation Working Group (MfE 2017), there are several information gaps within the health sector that pose significant barriers to effective action. In particular, there is currently limited understanding by health sector decision-makers about the cumulative effect of climate change impacts on existing health inequities (Blakely et al. 2004), particularly for Māori (Borell et al. 2009). There is also limited understanding of the psychosocial impacts of climate change on the Aotearoa-NZ population in general, which implies a limited understanding of the nuances for the Māori population.

Māori values and principles continue to lie at the peripheries of health policy and practice. While there appears to be a high commitment to engagement with Māori in health policy, understanding Māori values and principles is often superficial (Prussing & Newbury 2016; Williams 2018). Consequently, this knowledge is often under-valued, and its application is often tokenistic (Came et al. 2019; Zambas & Wright 2016). The current market-based, individually focused orientation of the health sector overrides and marginalises Indigenous ecological models that could advance hauora Māori, equity, and sustainability (Macmillan and Jones, 2018). Customary practices such as the medicinal use of native plant life are also undervalued and under-resourced in current health structures (Aichele 2016). Māori medicine and practice [rongoā] incorporate multiple dimensions within a complex relational system of health and well-being. Protection of indigenous ecological and customary resources, their associated intellectual properties, and biodiversity are captured within the WAI262 claim (Sullivan & Tuffery-Huria 2014). Access to natural resources, including medicinal plants, and the intergenerational transmission of knowledge that nurtures the whakapapa connections within plant ecosystems and communities, is essential for kaitiakitanga (duty of care for our environments). These connections are fundamental to health and well-being and promote medicinal practices that can heal both people and the land, all directly strengthening our relationship with the whenua (Harmsworth & Awatere 2013).

The development of *He Korowai Oranga,* the National Māori Health Strategy (Ministry of Health 2014) and, recently, *Whakamaua Māori Health Action Plan* (2020–2025) to guide implementation of the strategy, are potentially promising shifts in the health system. He Korowai Oranga articulates the need to link Māori health and aspirations [wai ora] to environmental well-being, alongside whānau ora [family well-being] and individual well-being [mauri ora], with mātauranga Māori as an essential basis. *Whakamaua* prioritises four key principles: 1) the health and disability system authorises whānau/hapū/iwi to improve their own health and well-being; 2) the health and disability system is fair and sustainable and delivers more equitable outcomes for Māori; 3) the health and disability system addresses racism and discrimination in all its forms; and 4) the health and disability system includes and protects mātauranga Māori throughout. However, this strategy and action plan have not yet fundamentally transformed the health sector, and to date there is little evidence of any significant shift in approach.

Adaptation Strategies

Public health sector and District Health Board strategies and policies need to better reflect the Treaty of Waitangi partnership. Climate change adaptation strategies should be deliberately oriented towards partnership principles from both *He Korowai Oranga* and *Whakamaua,* thereby enabling Māori self-determined approaches to well-being and resilience. In particular, approaches promoted by the *Whakamaua* action plan are relevant for supporting climate-change-related Māori health priorities. For example, *Whakamaua* advocates a systemic shift to better enable different whānau/hapū/iwi to thrive. This means disestablishing systemic monocultural perspectives for addressing public health, embracing Māori perspectives, and enabling iwi and hapū to lead Māori health development. Improving the connection between people and ecosystems, and lifting the mauri [life-force, condition] of ecosystems, also represent opportunities to achieve better health outcomes. These strategies can be supported by communities and achieved through a range of practices that promote restoration and connection to resources, including tree planting, wetland and mahinga kai enhancement, and rongoā Māori [Māori medicine]. Consistent with principles of kaitiakitanga, tree planting schemes like Te Uru Rākau[12] (One Billion Trees) are an opportunity to improve relationships between people and ecosystems and make landscapes/whenua/Papatūānuku more resilient to climate change. With the focus of Te Uru Rākau on planting and restoration of indigenous species, it is also an opportunity for whānau/hapū/iwi to engage more with non-timber-based activities such as rongoā Māori.

[12] Te Uru Rākau is an afforestation scheme that aims to double the current planting rate to reach one billion trees by 2028, with a focus on the right tree, in the right place, for the right purpose (MPI 2020). Funding totalling $240 million is available for tree planting by landowners, two-thirds of which is earmarked for indigenous species: www.mpi.govt.nz/forestry/about-te-uru-rakau/

Table 4. He Arotake Tūraru – He Oranga Tangata, Healthy People

Sector	Group	Interests	Risk		Adaptation strategies
Māori health status and inequities	Individuals, whānau	Minimising health risks of climate change; maximising health co-benefits of climate action	Now	Moderate	• Individual/whānau level: walk/bike, use public transport, reduce meat and dairy consumption, and increase plant-based diets, ensure homes are insulated and energy-efficient. • Communities – cut back on deforestation, plant trees, design towns/cities to encourage healthy, low-carbon transport, develop renewable energy systems (wind, sun), build healthy, energy-efficient housing, establish community food gardens, improve waste and recycling systems.
			2050	Major	
			2100	Major	
Institutional health systems	Mainstream health providers, Ministry of Health	Equity	Now	Moderate	• Reorient systems to better enable iwi, hapū and whānau to thrive as Māori, create healthy and sustainable environments in which to live and raise children • Dismantle colonial structures and systems that privilege Eurocentric values • Recognise the relevance and value of distinctive Māori knowledge systems and indigenous ways of knowing, being and doing that are embedded in kaupapa Māori models of care including rongoā Māori • Establish meaningful Māori – Crown partnerships • Ensure Māori health development is led by iwi and hapū, including both Māori health sector development and intersectoral action
			2050	Major	
			2100	Major	
Māori identity and health	Iwi, hapū, whānau trusts and incorporations, central government	Natural health, mental wellbeing, social connectivity	Now	Moderate	• Support mana whenua governance and kaitiakitanga of natural resources • Harness ecological restoration through tree planting to help reconnect Māori to the land, thereby strengthening mātauranga Māori and Māori systems of healing • Realise non-timber-based products like rongoā Māori through replanting Indigenous species
			2050	Major	
			2100	Major	

6 Kaupapa Māori Risk Assessment: Ahurea Māori, Tikanga Māori – Māori Culture and Practices

Māori culture and practices are dependent on the stability of social and cultural arrangements and, more fundamentally, on interactions with the natural environment. Direct and indirect climate change impacts are expected to alter the way Māori interact with the natural environment, each other, and other communities. This section explores the risk from potential impacts of climate change on Māori culture and practices, with particular emphasis on language and customs, sports, festivals, mourning ceremonies, and cultural infrastructure. A risk assessment (Table 5) is given for this domain at the end of this section.

Te Reo Me Ona Tikanga – Language and Customs

Te reo and tikanga are deeply connected to the natural environment. Narratives and proverbs resonate within cultural landscapes and often signify the importance of keystone species and other landscape features to different whānau/hapū/iwi (Kawharu, 2009). However, terrestrial, freshwater and coastal marine environments are under substantial pressure from existing land-use change, pollution, introduced predators, invasive plants and pests, and these challenges are greatly impacting the ecology of flora and fauna as well as Māori lifeways and values. Projected incremental and abrupt changes in climate this century are expected to exacerbate many of the risks facing different flora and fauna, and in some cases vulnerable keystone species may face extinction (Reisinger et al. 2014; Renwick et al. 2016; Egan et al. 2020). This poses risks for the maintenance and transfer of traditional skills, expertise and values relating to mahinga kai [wild food, gathering of wild kai] and has implications for language retention, tribal identity and wellbeing (King et al. 2010; Jones et al. 2014; Bond et al. 2018)[13]. Cascading risks include the loss of customary knowledge about environmental constraints and ecological principles, and potential grief and anxiety about failing to meet fundamental obligations to other species and provide for future generations. Notwithstanding these risks, it is important to recognise that many factors influence the loss of language, customary practices and values, and it can be difficult to distinguish the effects of climate change from other social, political and environmental drivers.

[13] There is a growing interest among many whānau/hapū/iwi to rediscover the Maramataka [lunar cycles and calendar] as a way to schedule customary resource use and reconnect with the activities critical to the well-being of whānau/hapū/iwi (Tawhai 2013; Hikuroa 2017). Such systems provide guidance and controls for fishing, hunting, gathering kai moana, and planting and harvesting food. However, shifting seasons and increased variability under climate change pose risks to the efficacy and application of these cultural systems (King et al. 2005). Further work is required to explore how cultural systems like maramataka might be impacted by climate change.

Figure 13. Iritekura Marae: Image: Radio Ngāti Porou.

Most landscapes have waiata [songs], pūrakau [narratives], whakatauki [parables], and karakia [prayers] associated with them that inform about human-environment history, claims to place, and risk. Climate-change-related damage, modification, and/or permanent loss of cultural locations and features, especially sites of significance, may therefore also affect the retention of specific forms of language and customary practice. For example, sea-level rise is not only likely to damage cultural sites through processes such as coastal erosion, storm surge, and flooding, it is also likely to force some whānau/hapū/iwi in at-risk areas to seek alternative locations, intermittently or permanently severing the link between whānau/hapū/iwi, whenua and taonga (Penny et al. 2007a, 2007b; King et al. 2010; Warmenhoven et al. 2014; Paul et al. 2016; Te Rūnanga o Ngai Tahu 2018; Bond et al. 2019). Such changes are expected to obstruct storytelling and the practise of culturally significant activities, and prevent obligations being met. Conversely, new waiata, whakatauki and korero may arise from these events and become part of whānau/hapū/iwi narratives. Among the potential strategies for dealing with detachment from places of historical and customary significance are formal and informal efforts by whānau/hapū/iwi to record and share waiata, pūrakau, whakatauki, and karakia associated with cultural landscapes. Any such strategies that can assist the maintenance, revitalisation and transfer of knowledge (and linked cultural values) to the next generation are central to ensuring that Māori lifeways continue and *whānau* can minimise risk and sustain themselves in the future.

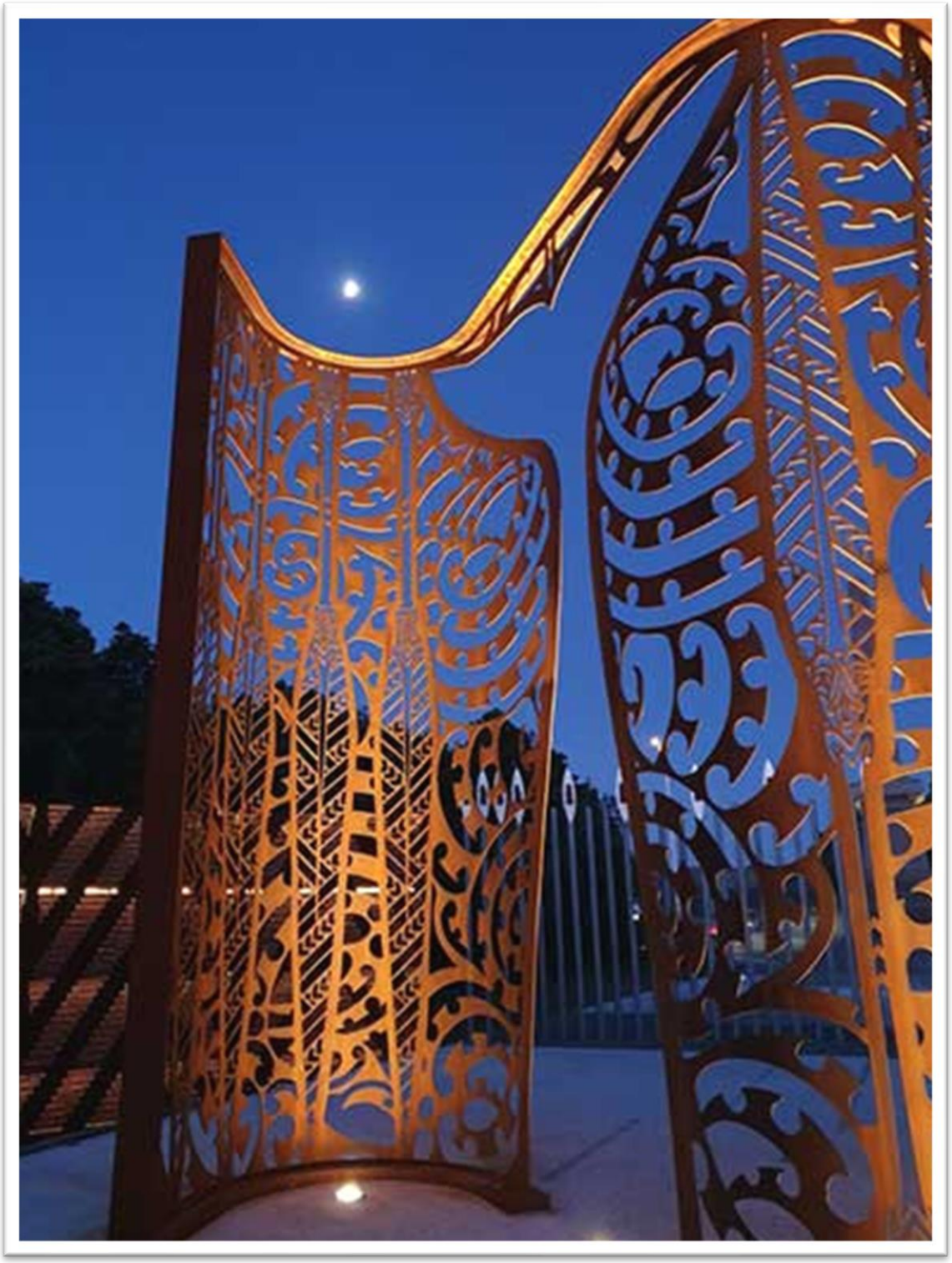

Figure 14. Te Ikaroa sculpture. Image: Jamie Quirk, DOC.

Ngā Hākinakina – Sports

Māori participate actively in a wide range of sports and leisure activities, with multiple positive outcomes for health, education and community. Changing weather and climatic conditions may jeopardise some future events. For example, the annual Tūrangawaewae Regatta on the Waikato River at Ngaruawahia, a major event on the Waikato-Tainui

calendar, requires adequate water flows to proceed. Projected warmer summers and low flows caused by reduced rainfall will place increasing pressure on the river from competing cultural, economic and human health demands, potentially jeopardising the regatta.

Shifts in hydrological regimes due to changing rainfall patterns, compounded by nutrient loading from urban and rural lands, could also make conditions in rivers and lakes more suitable for algal blooms that degrade water quality and present health risks to aquatic life and people (Renwick et al. 2016; MfE, 2019b). In addition, warmer and drier summers are projected to reduce some lake levels and raise water temperatures, which strongly influence the growth of cyanobacteria and harmful algal blooms (Roberts et al. 2015). Such impacts are likely to raise health and safety risks for fishing and boating events such as the Waka Ama National Sprint Championships held annually at Lake Karapiro. In 2018 the swim leg of the Iron-Māori competition was cancelled due to an algal bloom (May 2018). Moving the swim leg of such multisport events to a swimming pool or cleaner site may be a necessary adaptation to mitigate health risks.

Extreme heat also presents health risks for athletes performing in summer sports like touch rugby, softball, cricket, and athletics (Climate Central 2019). Māori participation in touch rugby is particularly high (Te Puni Kokiri 2006). Organisers of Māori touch rugby tournaments will likely need strategies to mitigate heat exhaustion and heat stroke, especially during hot and humid weather. The higher the humidity, the more difficult it is for athletes to cool down because sweat cannot evaporate easily (Climate Central 2019). Tournament games may have to be played earlier in the morning or late in the evening to avoid the daytime heat. More regular drinks breaks may also be required (RWC Staff 2019). A warmer drier climate may also make ground conditions for contact sports like rugby, rugby league, and touch rugby much harder, elevating the risk of injuries (Gabbett et al. 2007; Takemura et al. 2007). Managing such conditions is likely to become increasingly important.

Sea-level rise and coastal erosion are also expected to impact some nationally recognised surf breaks (Black 2001; Bell et al. 2017), potentially affecting events like the Aotearoa Māori Surfing titles (Orchard et al. 2019; Waiti & Awatere, 2019). Such events are a source of pride for many whanau/hapū/iwi groups, and reduced wave quality will impact on opportunities for different whanau/hapū/iwi to manaaki visitors. Conversely, new surf breaks may develop as the geomorphology of different coastal locations change in response to rising sea levels, erosion and sedimentation. Moreover, big wave surfing events may benefit from bigger, more powerful waves induced by more extreme low-pressure systems (Young & Ribal 2019). Further work is required to explore the risks to nationally significant surf breaks from climate change.

Figure 15. Ngāti Porou Pa Wars. Image: Ngātiporou.com.

Ngā Hui Ahurei – Festivals

Festivals like kapa haka feature on the calendars of many whānau/hapū/iwi and Māori organisations. However, outdoor festivals are weather- and climate-sensitive, and projected changes this century are likely to increase the risks for spectators, competitors, and infrastructure. For example, Aotearoa-NZ's premier kapa haka festival is held biannually during the cyclone season between November and April. In 2019, ex tropical cyclone Oma brought heavy rain and strong winds to the festival host city - Te Upoko-o-te-Ika [Wellington] – causing significant disruption and safety concerns during the final days of the competition (Roes, 2019). While contingency planning is already a central part of organising such events, the changing risks presented by climate-induced extremes will likely place new demands and responsibilities on organising teams. Event managers will need to consider the increasing likelihood of extremely hot weather and drought during summer festivals. Logistical planning will need to factor in the availability of sufficient drinking water, sunscreen, water and hoses at stages, and shaded areas for participants (Delaney 2019). Alternatively, managers might have to minimise risks by holding such festivals indoors.

Figure 16. Te Matatini Festival 2019. Image: Rebekah Parsons-King, RNZ.

Ngā Tangihanga – Mourning Ceremonies

Tangihanga are an important custom for Māori families and communities to express grief and farewell the dead. Climate change is likely to have both direct and indirect effects on the coordination of, and participation in, these cultural arrangements. Direct effects relate to extreme heat and flooding caused by higher rainfalls that present risks to life, transport, access, and property. Coordinators of tangihanga may need to be more cognisant of such risks when planning and managing events. Some marae may require cooling facilities such as air-conditioning or shade infrastructure – either natural, such as indigenous trees, or artificial, such as shade sails. Many urupā [burial grounds] in low-lying coastal areas also face risks from rising sea-levels, erosion and inundation (Reisinger et al. 2014; Manning et al. 2015). There is anecdotal evidence that rising water tables are already affecting urupā in some locations, requiring many whanau/hapū/iwi to grapple with difficult decisions about relocating tūpāpaku [the buried dead] to higher ground (King et al. 2010, 2013).

The indirect effects of climate change typically relate to the ability of whānau to participate in such cultural events (Royal Society 2017). Vector-borne diseases (e.g. mosquito- and tick-borne diseases) pose new health risks, especially when marae are located close to mosquito habitats. More extreme rainfall events and higher temperatures, coupled with nitrogen runoff from farms, are also likely to increase the transmission of pathogens and disease through contaminated drinking water (Royal Society 2017). This represents a significant risk for rural communities and marae who source water from unreticulated and unfiltered systems such as tank water and/or groundwater wells in intensively farmed areas. This risk can be heightened during extreme hot weather and

drought. Marae will need to supply enough drinking water for attendees, which may be difficult if rainwater tanks or groundwater wells have been compromised. Toxic algae blooms are also expected to occur more frequently during warmer weather and prolonged periods of dryness, potentially impacting on the availability of cultural keystone species (e.g. pāua, kina and kōura) for marae-based events. The inability of whānau to manaaki [care, give hospitality, look after, protect] visitors with customary resources is likely to impact Māori customary practise, cultural identity, and well-being (Jones et al. 2014; Warmenhoven et al. 2014).

Figure 17. Tangihanga for Dr Apirana Mahuika at Rahui marae. Image: Ngātiporou.com.

Pouhere Taonga – Cultural Infrastructure

Climate-change-induced sea-level rise in coastal areas is expected to exacerbate damage to cultural infrastructure and kainga [settlements] already vulnerable to coastal erosion or coastal flooding (Hennessey et al, 2007). More frequent and intense weather events with high rainfall are also expected to increase flood risk for cultural assets and interests in flood-prone catchments. Several hapū/iwi in low-lying coastal areas and/or river valleys are already evaluating projected climate change impacts and risks to cultural infrastructure and deciding how to integrate these into hapū and iwi development plans that include many and varied objectives (King et al. 2011, 2012, 2013; Colliar and Blackett, 2018[14]; Te

[14] Colliar and Blackett (2018) outline the development of a transferable Indigenous Climate Change Adaptation Decision Model, which captures the key decision-making processes, stages and sequencing involved for communities when facing uncertain and complex climate change impacts. The model is the result of a

Rūnanga o Ngāi Tahu 2018). It is likely that risks will be heightened in areas where communities have limited access to economic resources, including negligible or no insurance cover (ICNZ 2005, Allen Consulting Group 2005). Adaptation options include future-proofing existing cultural infrastructure by raising minimum floor levels in areas close to rivers and the sea, relocating cultural infrastructure away from floodplains and low-lying coastal areas, and restricting the building of infrastructure on flood-prone sites. Further analysis is required to better understand the extent of Māori communal and cultural assets that may be affected by climate-change-induced hazards.

Prolonged periods of low rainfall are also expected to increase drought risk in some regions, placing pressure on water availability and quality in some marae and communities (Hennessey et al, 2007; Tait et al. 2016). The most serious effects will be felt where reticulated supply systems are poorly developed (or non-existent), and where there are inadequate resources to import water or pay for private treatment facilities (Woodward et al. 2001; King et al. 2012; Henwood et al. 2019). A handful of communities, particularly in northern and eastern areas of the country, are highly vulnerable. In these locations, water supply planning and development would likely see immediate health gains as well as longer-term climate-change adaptation benefits (Woodward et al. 2001). In many situations, adaptation will require additional and ongoing financial support, as well as the transfer and uptake of technological capacity (King et al. 2010; Henwood et al. 2019). Climate-change-induced drought conditions can also increase the risk of wildfires, such as those that occurred in Christchurch's Port Hills in 2017 (Pearce, 2018) and the Tasman Region in 2019 (Radio NZ 2019b). These events also pose risks for cultural infrastructure and kainga [settlements].

collaborative project between the coastal hapū from Tangoio Marae, NIWA's Māori Environmental Research Centre and the Deep South National Science Challenge. Eight key steps are included in the model, which include (i) clarifying vision and objectives, (ii) understanding risks, (iii) identifying options to achieve community objectives, (iv) developing potential pathways, (v) evaluating pathways to support decisions, (vi) choosing pathway(s), (vii) implementation, (viii) monitoring and review.

Table 5. He arotake tūraru – Ahurea Māori, tikanga Māori

Sector	Group	Interests	Risk		Adaptation strategies
Te Reo me ōna tikanga	Iwi, hapū, whānau, pan-Māori	Language, practices, culture, and history	Now	Moderate	• Te Rautaki Reo Māori – The Māori Language Strategy has a module that reflects Te Ao Tūroa • Whānau, hapū and iwi are recording and sharing waiata, pūrakau, whakatauki, and karakia associated with cultural landscapes • Toi Māori to capture existing cultural landscapes (e.g. whakairo, mōteatea, waiata, pūrakau, and haka) • Riparian planting in coastal margins
			2050	Moderate	
			2100	Moderate	
Ngā Hākinakina	Iwi, hapū, whānau and pan-Māori	Sporting events	*Now*	Moderate	• Ensure rights to water flow rates are acknowledged • Move the swim-leg of multi-sport events to swimming pools or alternative sites with cleaner water to manage health risks associated with climate-induced low water flows and toxic algal blooms • Make facilities available to manage extreme heat such as enough drinking water, sunscreen, water, and hoses at stages. and shaded areas for participants • Hold tournaments earlier in the morning or late in the evening, ensuring that floodlights are available, and regular drink breaks are scheduled • Invest in insurance coverage for event cancellations and/or postponements
			2050	Major	
			2100	Major	
Ngā Hui Ahurei	Iwi, hapū, whānau and pan-Māori	Festivals	Now	Minor	• Create contingency plans for relocation of festivals • Hold festivals at indoor venues • Make facilities available to manage extreme heat such as enough drinking water, sunscreen, water and hoses at stages, and shaded areas for participants • Invest in insurance coverage for event cancellations and/or postponements
			2050	Moderate	
			2100	Moderate	
Ngā Tangihanga	Iwi, hapū and whānau	Mourning ceremonies	Now	Moderate	• Relocate marae, urupā, wāhi tapu and wāhi taonga • Invest in water treatment systems at marae • Improve access to vaccinations • Implement community-based health programmes that relate to vector-borne disease • Invest in cooling facilities for marae such as air-conditioning • Provide shade infrastructure – either natural such as indigenous trees or man-made such as shade sails
			2050	Major	
			2100	Major	
Pouhere Taonga	Iwi, hapū and whānau	Cultural and historical artifacts	Now	Moderate	• Relocate marae and tūpāpaku • Ensure marae and other taonga have insurance coverage • Plant trees to mitigate erosion and protect cultural landscapes • Future-proof existing infrastructure • Implement building restrictions • Support sustainable planning approaches • Protect and enhance coastal wetlands to store water and reduce flood impacts
			2050	Major	
			2100	Major	

7 Whakarāpopototanga – Summary

This report summarises the latest research and guidance surrounding observed and projected climate change impacts on whānau/hapū/iwi and Māori business in Aotearoa-NZ. It considers the implications of these changes, as well as options for mitigation and adaptation, for four domains of interest: He Kura Taiao – Living Treasures, Whakatipu Rawa – Māori Enterprise, He Oranga Tāngata – Healthy People, Ahurea Māori, Tikanga Māori – Māori Culture and Practices. Importantly, this report is not intended as an exhaustive analysis of this topic, but rather a sweep of recent research and guidance by multiple subject matter specialists to supplement the analysis presented in the first National Climate Change Risk Assessment (NCCRA, 2020).

The review identifies a total of 25 risks across the four domains, with risk ratings reflecting the degree to which Māori investments, livelihoods, health, culture, and the environment are exposed and vulnerable to sudden and/or slow-onset climate hazards and change. Changing climatic conditions are expected to pose minor to moderate risks for whānau/hapū/iwi and Māori businesses across all four domains by 2050 CE. However, by 2100 CE, these risks are expected to become moderate to major across all interests considered under all domains. Importantly, these domains and the risks identified are highly interconnected, and while some interconnections are identified in this report, more detailed work is required to understand how cross-domain relationships might influence the development of effective mitigation and/or adaptation actions in the future.

The work undertaken has identified significant gaps in knowledge, where further research is required to better understand and address the risks and opportunities. Understanding of how natural ecosystems and species will respond in the face of climate change is limited, as too is knowledge surrounding the vulnerability of taxa-specific species. Further, more detailed analysis is required to better understand the risks facing Māori investment (and employment) in climate-sensitive economic sectors. Valuation and location data on specific Māori investments will be required for such analysis. Urgent work is also needed to better understand the social, cultural, and fiscal implications of sea-level rise, including what duties local and central government might have with respect to actively upholding Māori interests under the Treaty of Waitangi. A coordinated platform to inform adaptation decision-making also needs to be developed as a high priority, to ensure research and guidance is accessible, and that climate-change-related opportunities can be understood and realised.

Notwithstanding these gaps and uncertainties, social-cultural networks and conventions that promote collective action and mutual support are central features of many Māori communities. These entities and practices will continue to be invaluable for initiating responses to, and facilitating recovery from, climate change stresses and extreme weather events. Māori tribal organisations will also continue to define Māori priorities for climate change mitigation and adaptation, as well as enter strategic partnerships with business, science, research, and government. We expect that intergenerational approaches to future climate planning and policy will also become increasingly important, elevating political discussions about conceptions of diversity that recognise non-human entities with rights in law, and challenging the way people manage, relate to, use, and value the natural world and its resources.

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