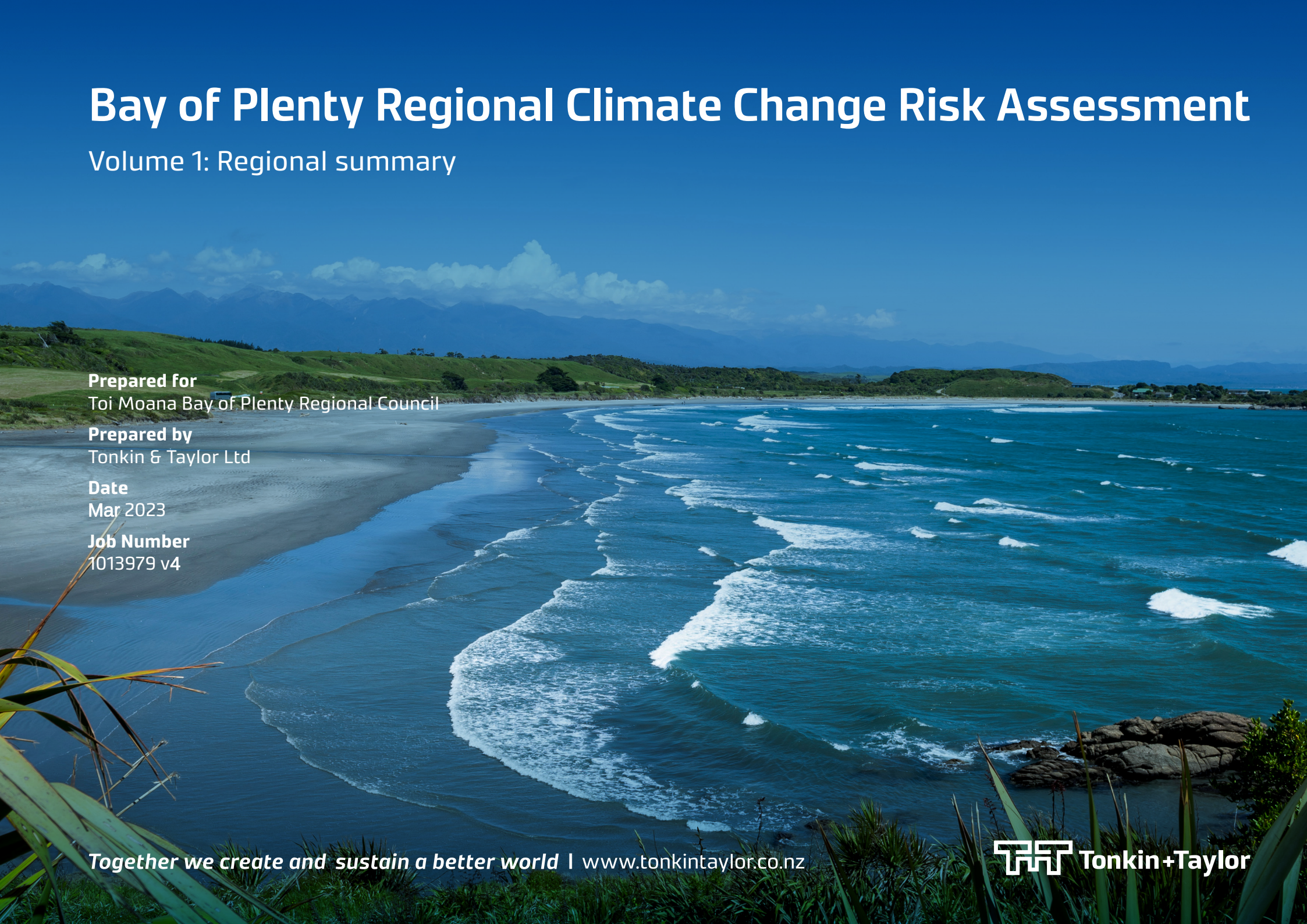
Bay of Plenty Regional Climate Change Risk Assessment

Volume 1: Regional summary



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1 Introduction

Climate change is predicted to have significant and wide-ranging impacts to communities within the Bay of Plenty region. Increases in the frequency and intensity, and duration of extreme weather events (e.g., heatwaves, droughts, floods, and storms) have the potential to impact many aspects of the natural and built environment as well as cultural wellbeing and the economy within the region. Impacts to health and community are also identified, along with specific risks to Iwi/Māori. This Bay of Plenty Climate Change Risk Assessment (BOPCCRA) has been undertaken to identify and understand the climate change risks within the Bay of Plenty on behalf of Toi Moana Bay of Plenty Regional Council.

This project is important as it identifies and highlights areas which will need a focused effort to manage these risks. The **purpose** of this climate change risk assessment is to provide a regional overview of current and future climate risks. The outputs from this **work will**:

- Inform adaptation planning at a range of scales/by a range of parties.
- Raise community awareness.
- Support further element or location specific assessments.

As the first climate change risk assessment for the region, this assessment sets a baseline to collectively build upon and respond to climate change risks. For clarity, the project does not:

- Assess risks at a local scale.
- Address emissions reduction.
- Involve adaptation planning or transition.

The risk assessment process was guided by the following broad **principles**:

- Collaborative, qualitative approach, with input from key specialists and stakeholders.
- Transparency of process to inform the risk assessment and clear recording of the process so that it can be readily understood by others (and therefore is replicable).
- Alignment with and acknowledgement of the National Climate Change Risk Assessment (NCCRA) process and outcomes.
- An iterative approach, with mechanisms for reviewing the process if basic assumptions change through unforeseen circumstances or if new information is presented.
- Consistency with national standards and guidelines, and clear recording and justification of where departures have been made.
- Technical assessment of risk that will assess and rate risks but not prioritise these.

The BOPCCRA was carried out in accordance with Ministry for Environment (MfE) guidance document for local climate change risk assessments[1] through the following phases (see Appendix A for detailed methodology):

1 Identification of potential climate change risks to the region followed by a detailed assessment of these risks through expert elicitation with subject matter experts.

2 Documentation of Māori perspectives on climate risk through two online hui, literature review and two case studies.

3 Geospatial exposure assessment of certain elements to coastal erosion, coastal flooding, and river and surface flooding).

[1] Ministry for the Environment. 2021. A guide to local climate change risk assessments. Wellington: Ministry for the Environment.

The outputs of this assessment are structured into three volumes, with supporting Appendices, as follows.

- Volume 1: Regional Summary.
- Volume 2: District Summaries.
- Volume 3: Sector Summaries.
- Appendix A: Methodology.
- Appendix B: Detailed risk assessment workbook.
- Appendix C: Perspectives on climate change risks to Māori in the Bay of Plenty and Waiōhau Marae case study.

This volume provides an overview of the assessment and summarises key risks and consequences to the region. The volume is structured to provide context relating to climate projections for the region (Section 2) a summary of the economic activity and demographics of the region (Section 3), followed by a summary of climate risks to the region (Section 4). Māori perspectives on climate risk are outlined in Section 5. Consequences of climate change risks to the region are discussed in Section 6, followed by Next steps (Section 7).

Volume 2 provides a summary of risks to each district. Districts included in the assessment are Tauranga City, Western Bay of Plenty District, Whakatāne District, Rotorua Lakes Council, Ōpōtiki District, and Kawerau District. While a part of Taupō District extends into the Bay of Plenty, this district is not assessed, as the main centres of the district are located within the Waikato Region.

Volume 3 provides summaries of the detailed risk assessment findings and is structured by sector. Each summary includes identified consequences and next steps that are relevant to that sector. Sectors are structured as follows:

- Ecosystems: Terrestrial, freshwater, coastal and marine.
- Water availability & quality.
- Three waters infrastructure.
- Flood management.
- Waste management.
- Transport infrastructure: Roads, walkways, cycleways, rail, airports, ports.
- Energy and telecommunications.
- Economic industries: Tourism, agriculture, horticulture, forestry and fisheries.
- Archaeological sites.
- Health.

Appendix A: Methodology contains a summary of methods used in carrying out the key steps of the assessment:

- Getting started and setting up the assessment.
- Risk identification.
- Detailed risk assessment.
- Geospatial exposure assessment.
- Perspectives on climate change risks to Māori.

Appendix B: Detailed risk assessment workbook is a documentation of all risks identified to the region, and documents the information gathered relating to each risk throughout the course of this assessment. The workbook contains a risk description, risk rating, and notes relating to the justification for each risk rating.

Appendix C: documents additional findings from the iwi/Māori workstreams. It includes a documentation of Māori perspectives on climate risk as gathered during hui at the risk identification phase of the project. It also includes a detailed documentation of the information gathered from the Waiōhau Marae case study workstream.

2 Climate change projections

The main driver of climate change relates to emissions of carbon dioxide into the atmosphere, which has been extensively modelled by the Intergovernmental Panel for Climate Change (IPCC). Based on IPCC models and reporting from their fifth assessment report (AR5), four **Representative Concentration Pathways**[2] (RCPs) were defined, providing greenhouse gas concentration trajectories to the end of the century (Figure 2.1).

The IPCC's sixth assessment report (AR6) introduced the Shared Socio-economic Pathways (SSPs) which are similar to the RCP scenarios; the RCPs effectively set pathways for greenhouse gas concentrations whilst the SSPs outline how global society, demographics and economics might change over the next century, determining the levels of mitigation that may be achieved. These SSPs are not currently modelled at a national or regional level, therefore the RCP scenarios have been utilised in this assessment in accordance with advice from the Ministry for the Environment[3].

- The 'Fossil-fuel intensive scenario' (RCP8.5 or SSP5-8.5) broadly aligns with emissions-reduction practice over the past few decades. It reflects high emissions, limited mitigation measures and no global emissions reduction policy settings. This scenario represents an average rise in global air temperature of 4.4°C by 2100.
- The 'Middle of the road scenario' (RCP4.5 or SSP2-4.5) reflects moderate emissions and implementation of current global emissions reduction policy settings. This scenario represents an average rise in global air temperature of 2.7°C by 2100.

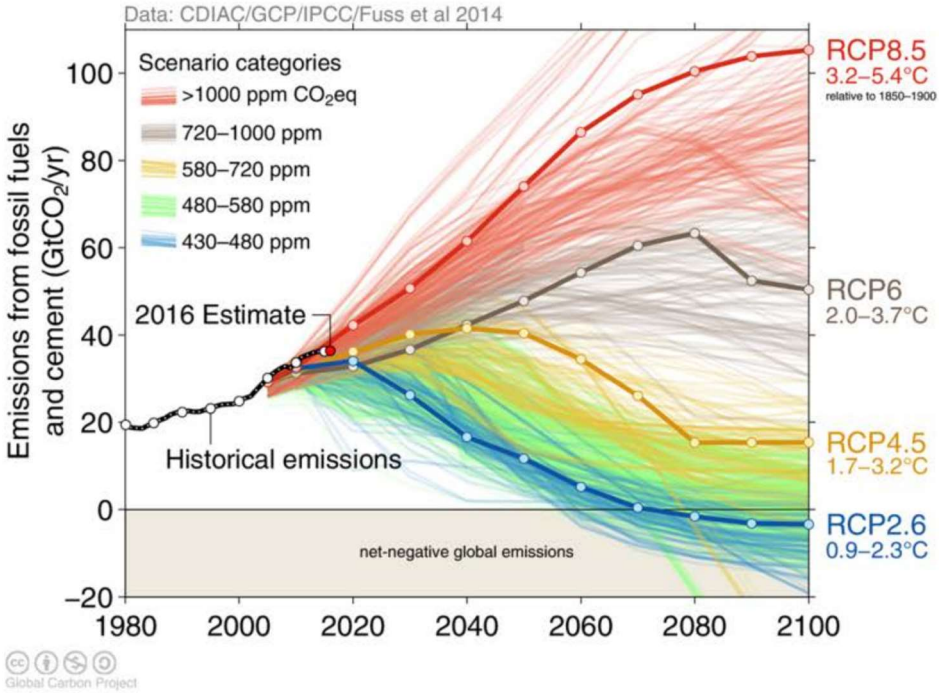

Figure 2.1: Global emission scenarios and the four RCP, with the historic emissions trajectory since 1980 (black), MfE 2018.

[2] The New Zealand government is currently updating the climate change projections under the IPCC's Sixth Assessment Report (AR6) projections.

[3] Bodeker et al,. (2022). Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings. Prepared for the Ministry for the Environment, Report number CR 501, 51p Climate-Change-Projections-Guidance-FINAL.pdf (environment.govt.nz)

For this project, the following hazards were used:

- **Temperature increases and drought:** higher temperatures, changes in the number of hot days and frost days, changes in variability of rainfall, drought and increased fire weather.
- **Flooding and extreme rainfall:** increased extreme rainfall and flooding, extreme weather (wind and storms), and increased frequency of landslides.
- **Coastal hazards:** sea level rise (including Vertical Land Movement (VLM))[4, 5, 6] coastal erosion, coastal flooding, groundwater rise, salinity stress, marine heatwaves and chemistry changes.

Projected changes in climate for Bay of Plenty[7] have been developed by NIWA, based on the IPCC AR5 report (2014). The key information is summarised below (Figure 2.2).

[4] VLM has the potential to change the effects of sea level rise, with subsidence increasing the depth and bringing forward the timing of sea level rise impacts, and uplift decreasing the effective depth and pushing out the timing of observed sea level changes. VLM rates, sourced from NZSeaRise[4] have been developed using datasets that are short relative to the duration of this assessment[4]. Precise levelling data for specific sites over extended time periods may provide increased confidence in the rate of vertical land movement over the time periods considered in this assessment.

[5] Maps — NZ SeaRise Programme

[6] Ministry for the Environment. 2022. Interim guidance for voluntary climate change mitigation. Wellington: Ministry for the Environment.

[7] Pearce, et al., (2019) Climate change projections and impacts for the Bay of Plenty Region. NIWA.

	Hazard	Description	Present day	2050 RCP4.5		2050 RCP8.5		2100 RCP4.5		2100 RCP8.5	
Temperature increases and drought	**Higher temperature**	• Significant seasonal variability exists both in present day and future change. • Spatial variability exists with Maketu, Murupa and coastward of Kawerau are expected to better hotter than most places. • Hot days are defined as days with 25°C or greater. • Frost days are defined as days when the daily minimum temperature drops below 0°C.	• Median ~15°C • 25-40 hot days • 0-60 frost days		+ 0.5°C + 0-25 hot days Up to 10 fewer frost days		+ 1.0°C + 0 to 25 hot days Up to 10 fewer frost days		+ 1.5°C + 30 to 40 hot days Up to 15 fewer frost days		+ 3.0°C +70 to 80 hot days Up to 30 fewer frost days
	Drought	• Drought is expected to become more common and more severe in Tauranga and Te Puke areas compared to the Uruwera and Raukumara ranges. • An increase in the number of dry days is expected for most of the BOP region. Autumn is typically the season where the largest increase is expected.	• 120 to 240 dry days (i.e. <1mm)		- 2 to + 6 dry days (coastal) +4-6 dry days (inland)		+ 4 to 6 days most areas		+ 8 to 10 days most areas		+15 to 20 days most areas
	Increased fire weather	• Fire risk is projected to increase due to increasing temperatures, lower rainfall and more drought.	• 7.7 days of Very High and Extreme forest fire danger days	50-100% increase				50-100% increase			
	Annual rainfall & rainfall variability	• By 2090 under RCP 4.5 annual rainfall decreases are pronounced for inland and western coastal areas. Under RCP 8.5 annual rainfall is set to decline for the whole region by 2-6%.	• Rainfall depth for a 24hr, 100-year event typically varies from 230- 370 mm		- 8% to - 15% in summer rainfall		- 8 to - 15% in summer rainfall +8% to 10% winter rainfall		+8% to 10% winter rainfall		- 10% to - 15% summer rainfall + 4% to 8% in winter rainfall
Flooding and extreme rainfall	**Rainfall and flooding**	• Maximum 1-day and 5-day rainfall is generally projected to increase, with larger extents of increase by 2090, particularly around Urewera and Raukumara Ranges. • Extreme, rare rainfall events are likely to increase in intensity in the BOP Region. This will drive an increase in associated extreme flood events.	• Rainfall depth for a 24hr, 100-year event typically varies from • 230- 370 mm • Inland flood modelling available for some areas within the region. Refer to Appendix A for details		+ 6% rainfall depth (24hr, 100yr)		+ 9% rainfall depth (24hr, 100yr)		+ 7% rainfall depth (24hr, 100yr)		+18% rainfall depth (24hr, 100yr)
	Extreme weather events (wind & storms)	• While the overall trends indicate a reduction in mean windspeed (MWS), storms in the BOP may have stronger circulation, leading to stronger winds and storm surge. • Summer storms are predicted to be more frequent and produce larger rainfall accumulation. Whilst winter storms are predicted to decrease wet spells are to be short-lived but more intense.	• 4.9m/s MWS		-2% to -4% MWS in summer + 0-1 % MWS in spring		-3% to -6% MWS in summer + 1-3 % MWS in spring		-1% to -3% MWS in summer		-6% to -10% MWS in summer + 1-2 % MWS in spring
Coastal hazards	**Sea level rise (SLR)**	• SLR in the 20th century at Moruriki was 1.90mm/year [+- 0.25mm]. • When assessing SLR, vertical land movement (VLM) should be considered as outlined in MfE (2022) Interim guidance on the use of new sea-level rise projections. • VLM is variable across the coastline: Western Bay from Matata: typically neutral or uplifting, with up to +5.0 mm/yr (uplift) near Maketu-Pongakawa. Eastern Bay from Matata: typically slight uplift, neutral or subsidence, with up to -3.0 mm/year (subsidence) near Matata.	• Represented by mean high water spring tide 10%								
	Sea level and groundwater rise	• Groundwater recharge may decline in the future due to projected reductions in soil moisture and mean annual low flow and increases in potential evapotranspiration deficit. • Coastal aquifers may also be affected by sea-level rise in terms of flow velocities, shallow groundwater levels and increased salinity.	• Not modelled		+0.25m SLR		+0.30m SLR		+0.55m SLR		+0.80m SLR
	Coastal flooding	• The extent of coastal flooding in low lying coastal areas is projected to increase due to SLR.	• Represented by coastal flooding modelling from NIWA 2019. Refer to Appendix A for details								
	Coastal erosion	• The extent of coastal erosion is projected to increase in some coastal areas due to SLR.	• Modelling available for parts of the region. Refer to Appendix A for details								
	Salinity impacts	• Sea level rise may increase the extent to which the effects of salinity impacts are sustained.	• Inferred coastal flooding modelling from NIWA 2019								
	Ocean temperature	• Sea surface temperatures are increasing globally • Projections provided are for the South West Pacific and therefore don't necessarily incorporate local effects that would influence in coastal waters.	• 17.2°C	+1.0°C				+2.5°C			

Figure 2.2: Climate hazard projections for the Bay of Plenty[7].

3 Bay of Plenty regional context

The Bay of Plenty Region stretches along the coast from Waihi Beach to Cape Runaway and inland to Rangitāiki, spanning over 1,207,200 hectares. The region includes seven districts:

- Tauranga City.
- Western Bay of Plenty District.
- Whakatāne District.
- Rotorua Lakes Council (district extends into Waikato Region with main centres located within Bay of Plenty, therefore included in assessment).
- Ōpōtiki District.
- Kawerau District.
- Taupo (district extends into Waikato Region, with main centres located outside Bay of Plenty, therefore excluded from assessment).

The region is made up of coastal areas, mountainous areas, plains, and urban and rural development. There are numerous rivers and lakes within the region and active geothermal features. These features that give Bay of Plenty its beauty also present hazards such as flooding, and erosion.

The region has a population of 308,499 and the largest cities are Tauranga, Rotorua and Whakatāne. The district has experienced 30% growth in population between 2013 and 2018. Of the region's population, 31.8% is of Māori descent and 8.6% speak Te Reo Māori[8].

Bay of Plenty contributed approximately 6% to the national GDP in 2020[9]. A mix of activities contribute to regional GDP, including primary industries, manufacturing, owner-occupied and property operation.

Agriculture, horticulture, and forestry make up most of the primary industry sector within the region (Figure 3.1).

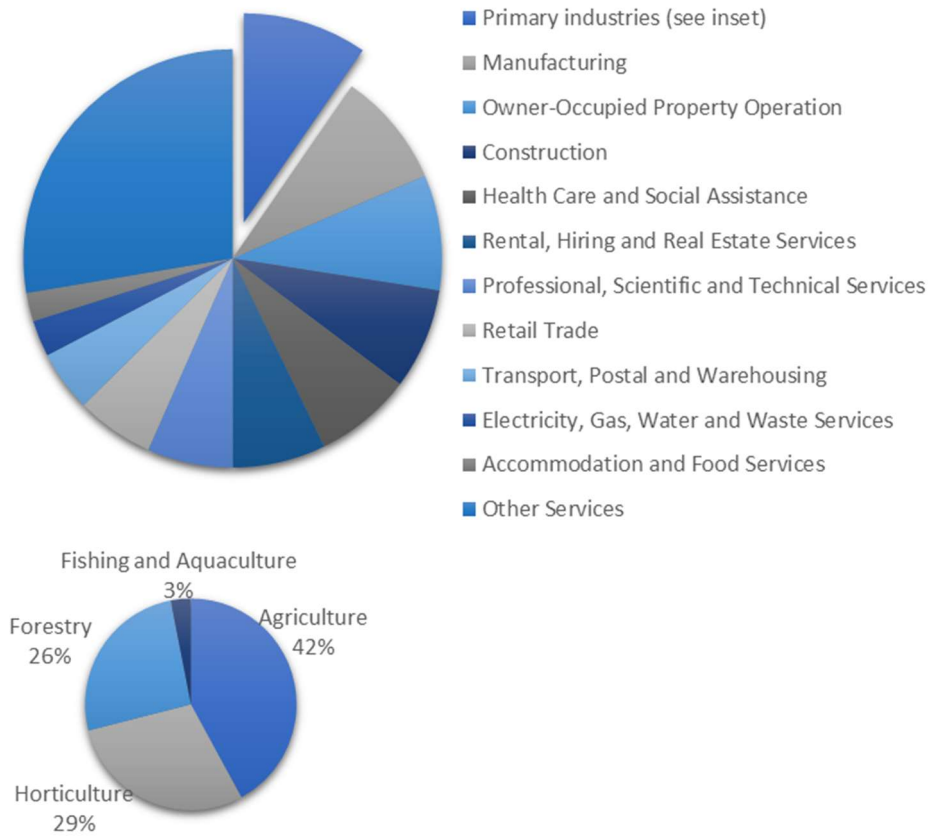

Figure 3.1: Summary of economic activity by percentage of BOP GDP (above). Proportion of GDP generated by each primary industry sector within BOP (right).

[8] Place Summaries | Bay of Plenty Region | Stats NZ

[9] Regional gross domestic product: Year ended March 2020 | Stats NZ

There are many socio-economically deprived areas within the Bay of Plenty, with many that are also exposed to climate-related hazards such as coastal erosion and flooding (Figure 3.2). Generally, these locations have poor accessibility and ability to respond to natural disasters (i.e., lower income levels, poor access to transport, lack of reserve food supplies, inequitable distribution of infrastructure etc.), therefore increasing their vulnerability. Lack of resources associated with socio-economically deprived areas can reduce the ability of these communities to prepare and/or respond.

[10] Source: Environmental Health Intelligence New Zealand EHINZ

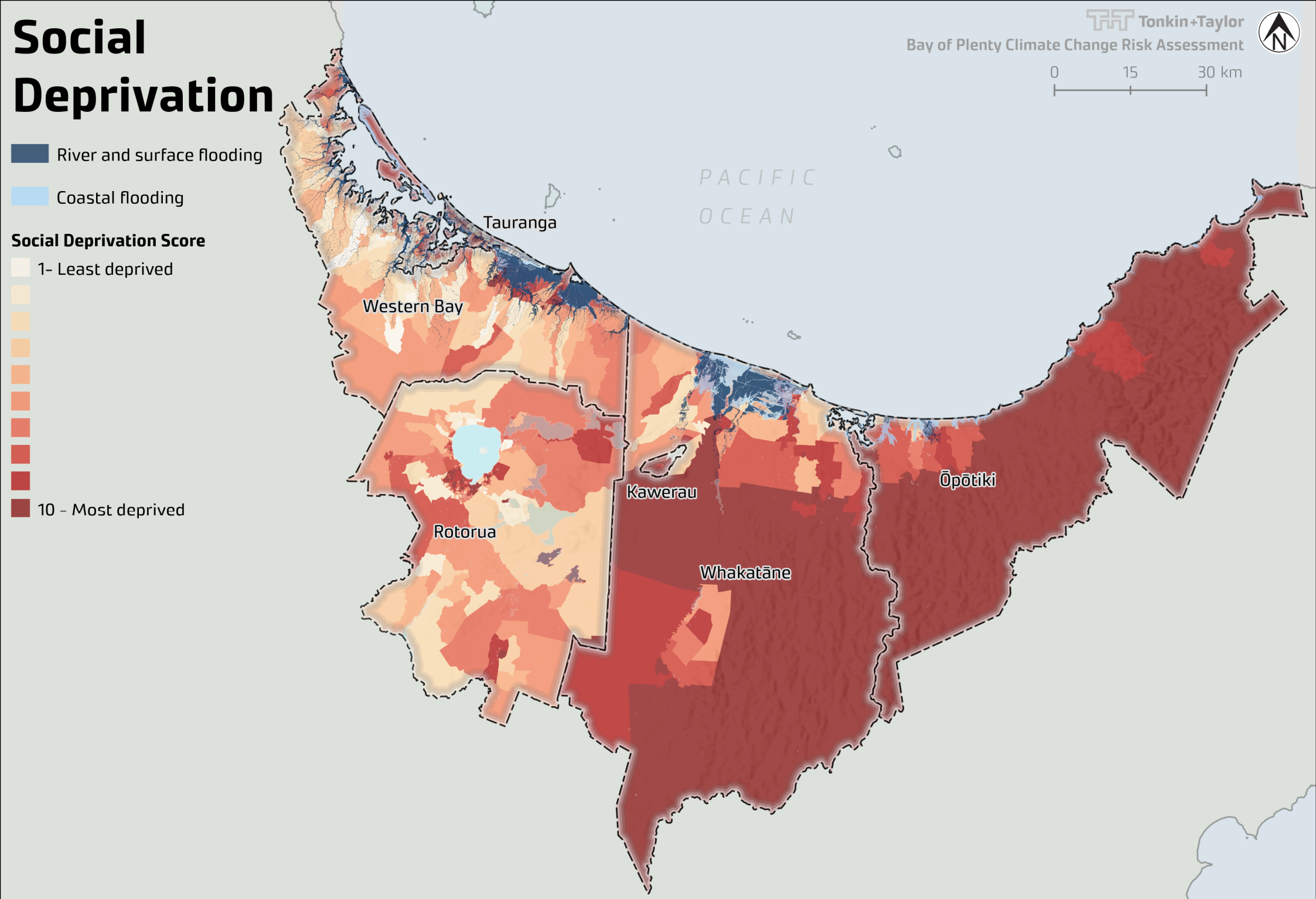

Figure 3.2: Social deprivation index of the region showing the extent of river and surface flooding and coastal flooding

4 Summary of climate risks to the Bay of Plenty Region

Summary of climate hazards associated with risks rated either 'high' or 'extreme' by late century that are specifically relevant to the region. Refer to Appendix B for the full detailed risk workbook and Volume 3 for risk assessment summaries by sector.

4.1 Summary of climate risks to ecosystems within the Bay of Plenty Region

Sector	Key climate hazards*	Risk description	Relevant sections
Terrestrial and freshwater ecosystems 	• Rainfall and flooding • Changes in variability and seasonality of rainfall • Increased temperature • Dryness and drought • Landslides • Soil erosion • Reduced frost days • Increased fire weather	The native ecosystems of the region are characterised by forests within the Kaimai Ranges, Te Uruwera Ranges, Raukumara Ranges, Central Plateau, frost flats (Kaingaroa Plataeu), the lakes, rivers, streams, and wetland ecosystems, the coastal lowlands, estuaries, harbours, dunes, cliffs and marine ecosystems. Increasing **temperatures** across all native ecosystems may result in species range shift, increasing stress, and loss of key species or whole ecosystem impacts. Increasing **severe weather, flooding, landslides and coastal hazards** may further damage ecosystems. Ecosystems that are currently degraded or stressed, such as the frost flats, some lakes, fragmented pockets of bush and many waterways, are likely to be severely impacted before others due to their current vulnerable state.	**Volume 3:** Ecosystems: Freshwater **Volume 3:** Ecosystems: Terrestrial
Coastal and marine 	• Sea level rise • Coastal flooding • Groundwater rise and salinity stress • Coastal erosion • Marine heatwaves and ocean chemistry changes	Increasing **severe weather, rainfall and flooding** may cause increased sediment to collect in downstream waterbodies such as harbours, estuaries, and near shore coastal habitats. Sediment smothers habitats and can block light which restricts photosynthesis. Marine environments are highly sensitive to **increasing temperatures and acidification**. **Temperature** impacts may result in widespread damage to many species across a range of marine environments and may contribute to a rise in invasive species.	**Volume 3:** Ecosystems: Coastal and marine

4.2 Summary of climate risks to settlements and communities within the Bay of Plenty Region

Sector	Key climate hazards*	Risk description	Relevant sections
Settlements and communities 	• Dryness and drought • Landslides • Extreme weather (wind and storms) • Rainfall and flooding • Groundwater rise and salinity stress • Coastal erosion • Sea level rise • Coastal flooding • Increased temperature • Increased fire weather	*This summary provides a summary of place based risks, however it is noted that settlements and communities will be affected by risks across all the sectors (e.g. disruption to regional transport connections, waste management and economic sectors*). The Bay of Plenty has many coastal settlements including Waihi Beach, Tauranga City, Matatā, Whakatāne, Ōhope, and Ōpōtiki that will be increasingly exposed to **coastal erosion, sea level rise and coastal flooding, and groundwater rise**. Many of these coastal settlements are also exposed to increasing **rainfall related flooding**, as are inland settlements such as Rotorua, Ngongotahā, Kawerau and Edgecumbe. Flooding and coastal hazards may threaten settlements and associated infrastructure and pose ongoing and worsening issues relating to road performance, landfills, water supply, stormwater and wastewater assets. The region has experienced **drought** at levels that impact water availability. Occurrence of drought is projected to increase which may further reduce water availability. Increasing occurrence of high **temperatures** may exacerbate water shortages, pose health risks and cause increased issues with waste odour. The greatest increases in hot days are projected for Waihi Beach and the coastal and inland areas between Matatā, Whakatāne, and along the Rangitāiki River.	**Volume 3:** Water availability & quality **Volume 3:** Three waters infrastructure **Volume 3:** Flood management **Volume 3:** Waste management **Volume 3:** Transport infrastructure: Roads, walkways, and cycleways **Volume 3:** Energy and telecommunications.
Cultural heritage 	• Coastal erosion • Extreme rainfall and flooding	Many marae, wāhi tapu sites, and sites of European historical value are located in low-lying and coastal locations and may be exposed to increasing **coastal hazards and flooding**. Climate change is likely to have a significant impact on Māori throughout the Bay of Plenty, affecting their ancestral lands, water, marae, urupā, cultural assets, taonga species, businesses, and in some cases further impacting household income levels.	**Volume 1 Section 5:** Māori perspectives on climate risk **Volume 3:** Archaeological sites
Health 	• Increased temperature • Increased fire weather • Dryness and drought • Rainfall and flooding • Groundwater rise and salinity stress	Climate hazards pose many risks to community health, some of which are direct risks to life and well-being and others are consequences that arise as a result of climate change impacts on the region. Increasing high **temperatures** may cause an increase in heat related illness particularly in kaumatua, ageing and other vulnerable groups. **Fire** can pose a direct risk to life from fire weather, including injury or death, and respiratory conditions (from ash). Increased **rainfall** can lead to **flooding** events which can increase the frequency of drowning and injury. Consequential risks to health and well-being can result from a rise in	**Volume 3:** Health

		waterborne diseases, contaminants in the water, loss of property, loss of livelihood, homelessness, stress, reduced access to care (including emergency services) and psychosocial stress. **Groundwater** rise can lead to dampness around houses which can lead to negative health impacts such as rheumatic fever, school sores and asthma. It may also lead to an increase in the presence of mosquitoes which can result in more vector-borne diseases. Increasing risks to health are likely to place greater pressure on existing health service delivery and support systems.	

4.3 Summary of climate risks to infrastructure within the Bay of Plenty Region

Sector	Key climate hazards*	Risk description	Relevant sections
Transport (airport, rail and state highways) 	• Sea level rise • Coastal flooding • Groundwater rise and salinity stress • Rainfall and flooding • Landslides • Extreme weather (wind and storms) • Increased temperature • Increased fire weather • Changes in variability and seasonality of rainfall	State highways form a network of critical transport routes across the region. These may face increasing damage and disruption from **rainfall related flooding**, **coastal erosion, and sea level rise and coastal flooding**. **Landslide** risk to roads and state highways may also increase, particularly in steep areas. Many of the region's state highways provide access to remote communities, for which there are no alternative access routes. Loss of access can prevent access to critical services and impact community wellbeing. The regional rail network may face similar increased disruption, as well as issues relating to stormwater management and dust at yards. Disruption to airports may increase due to **severe weather**, with possible loss of access to the airports and port due to **flooding** of surrounding roads.	**Volume 3:** Transport infrastructure: Roads, walkways, and cycleways **Volume 3:** Transport infrastructure: Rail **Volume 3:** Transport infrastructure: Airports and ports
Energy and telecommunications 	• Extreme weather (wind and storms) • Rainfall and flooding • Increased temperature • Dryness and drought • Landslides • Increased fire weather	Energy and telecommunications provide critical services to the region. **Extreme weather, fire weather, and landslides** may damage transmission, distribution and telecommunications infrastructure. **Dryness and drought** may lead to reduced water availability for hydro schemes and geothermal power generation, which may have consequences for regional power generation.	**Volume 3:** Energy and telecommunications

4.4 Summary of climate risks to economic industries within the Bay of Plenty Region

Sector	Key climate hazards*	Risk description	Relevant sections
Agriculture 	• Extreme rainfall and flooding • Landslides • Soil erosion • Soil loss • Dryness and drought • Increased temperature • Sea level rise • Coastal flooding • Groundwater rise and salinity stress • Increased fire weather	The region has a strong dairy, sheep and cattle farming industry. Farms are located across the region on hill country and coastal lowlands and may be exposed to a range of climate hazards. Increased **extreme rainfall** over the hill country may drive increasing erosion, resulting in soil and crop loss and ultimately reduce the productivity of the land. **Extreme events** may also damage property and crops, cause animal welfare issues, and can lead to loss of stock or loss of production. **Drought** and increased **temperature** may introduce animal welfare issues and increase pests and diseases. Lowland farms may be subject **to increased flooding** and loss of land **as sea level rise, coastal erosion, rising groundwater** and severe **rainfall** events increasingly impact farmland.	**Volume 3:** Economic industries: Agriculture
Horticulture (kiwifruit and avocado) 	• Increased temperature • Dryness and drought • Extreme weather (wind, storms, frost events and changing seasonality) • Extreme rainfall and flooding • Sea level rise • Coastal flooding • Coastal erosion • Increased fire weather • Groundwater rise and salinity stress	Kiwifruit and avocado orchards dominate the horticultural activity within the region and are a major economic driver of the region. These crops are primarily located within the Western Bay of Plenty, Whakatāne and Ōpōtiki. Projected increases in **temperature** and **reduced winter chill** may impact budbreak and fruit maturity. Warmer **temperatures** may increase **fire risk**, pose risks to worker health, and increase the occurrence of pests and diseases. It may also increase irrigation demands, which coupled with increased **drought** may contribute to regional issues relating to water availability. Increasing **extreme weather** (flooding, wind, storms, frost events and changing seasonality) and **groundwater rise** may increase damage to crops and interfere with harvesting practices.	**Volume 3:** Economic industries: Horticulture
Forestry 	• Increased fire weather • Extreme rainfall and flooding • Extreme weather (wind and storms) • Landslides	The region is home to the expansive Kaingaroa forest and other smaller forestry blocks, with associated industries also contributing to the region's economic activity. Forestry is at risk of damage from increasing e**xtreme weather, drought, landslides and fire risk,** as well as disruption to logging connections due to **flooding** of transport routes.	**Volume 3:** Economic industries: Forestry

	• Dryness and drought • Coastal erosion • Coastal inundation • Groundwater rise and salinity stress		
Fisheries 	• Marine heatwaves and ocean chemistry changes • Increased temperature • Dryness and drought • Coastal erosion • Sediment runoff • Sea level rise • Coastal flooding • Extreme weather (wind and storms)	The region has a strong and growing aquaculture industry, particularly in Ōpōtiki. **Sea level rise and storm surges** may cause damage to aquaculture facilities, particularly in more exposed coastal locations. Shellfish are at risk from increasing **sediment deposition** and **temperature increases,** which may impact oyster and mussel farm operations. Warming **temperatures** may increase biofouling, contribute to algal blooms and increase parasites, pests, and diseases that can result in shellfish toxicity. Wild catch and recreational fisheries are highly sensitive to warming temperatures and increasing sediment deposition related to stormwater runoff and coastal erosion.	**Volume 3:** Economic industries: Fisheries
Tourism 	• Increased temperature • Dryness and drought • Extreme weather • Extreme rainfall and flooding • Increased fire weather	Tourism within the region is dominated by seaside city attractions of Tauranga and the geothermal, cultural and adventure attractions of Rotorua. Increasing **severe weather and flooding** may cause the natural amenity of the region to decline or disrupt regional access and reduce tourism confidence in travel. **Drought** impacts on water availability may limit the capacity of the coastal settlements to accommodate seasonal tourism growth. **Fire** risk to forests, **temperature** related degradation of lake water quality, and **drought** impacts on geothermal attractions are key potential risks to Rotorua.	**Volume 3:** Economic industries: Tourism

5 Māori perspectives on climate risks

Climate change is likely to have a significant impact on Māori throughout the Bay of Plenty, affecting their ancestral lands, water, sites, marae, urupā, cultural assets, taonga species, businesses, and in some cases further impacting household income levels.

Māori demographics within the region and context relating to a Māori world view are provided below, followed by a summary of climate risks to Māori as identified through a national and regional literature review. This is followed by case studies of Maketu and Waiōhau Māori, that outline key climate risks that are specific to these communities.

5.1 Māori demographics in the Bay of Plenty

The Bay of Plenty is home to 35 iwi groups (iwi authorities, and/ or iwi rūnanga), over 230 hapū and over 200 marae (Figure 5.1). There are just over 102,000 Māori living in the Bay, making up almost a third of the population within the region. At a national level, this comprises the third highest Māori population of a region. In 2015, approximately 36% of land tenure in the Bay of Plenty was in Māori title, with over 5,000 parcels of Māori land across the region. There are approximately 1,800 land trusts in the region[11] and Māori own $8.9 billion of assets[12].

The Bay of Plenty has the second highest rate of Māori language speakers in the country with the medium age ranging between 20-27 years. A growing younger Māori demographic in the region is represented with a slightly higher percentage of females than males. The average income for Māori is between $19,000 – $25,000, with approximately 12% of Māori in the Bay holding a Bachelor's degree or higher (Stats NZ, 2018).

Māori contribute significantly to the Bay of Plenty region through their:

- ownership of notable assets, particularly in the horticulture sector.
- broader economic contribution.
- participation in co-governance.
- growing influence in the conservation, preservation and management of natural resources (Bay of Plenty Regional Council, 2022).

Significantly, within the Bay of Plenty, there have been several comprehensive Treaty settlements including Ngāti Awa Settlement (2004), Tuwharetoa ki Kawerau Settlement (2004), Te Arawa (affiliates) Settlement (2008), Te Arawa Lakes settlement (2005) and others (Bay of Plenty Regional Council). These iwi have the potential to significantly contribute economically, socially and culturally to the region.

Māori comprise 24.6% of the employed workforce within the Bay of Plenty, compared to the national average of 13.4%[12]. The top four sectors within which Māori are employed include administration and support services, health care and social assistance, education and training and construction services. With a growing economy and growing rangitahi (Māori youth) population, rangitahi are expected to play a significant role in future employment within the region, which has the potential to contribute to the wellbeing and future of whānau/hapū/iwi (Toi Kai Rawa, 2021).

[11] Bay of Plenty Regional Council, 2022

[12] Reserve Bank of NZ & BERL. 2018. Te Ōhanga Māori 2018: The Māori Economy. Report commissioned for central government.

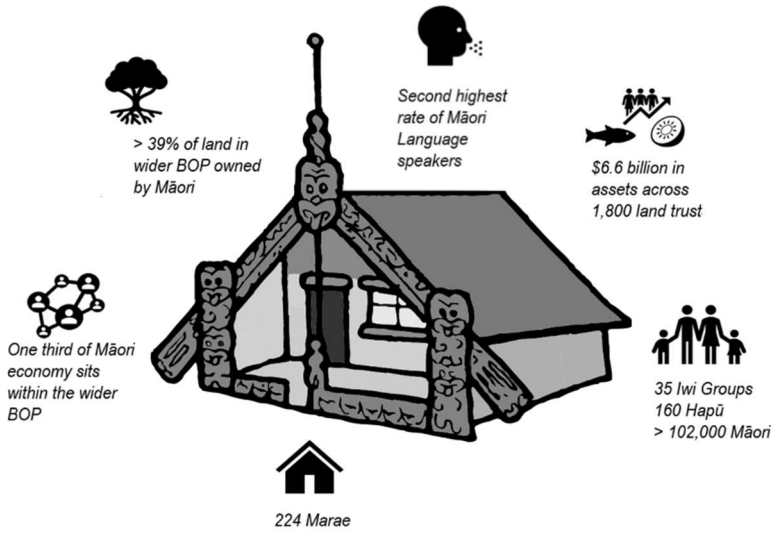

Figure 5.1: Summary of Māori demographics

5.2 A Māori world view

A Māori worldview is premised on the perspective that there is a relationship between the spiritual world, natural world, and humanity. From a Māori worldview perspective, the natural world and humanity sits within a hierarchical genealogical framing that includes the primordial parents – Ranginui (Sky Father) and Papatuānuku (Mother Earth). From this union, their offspring were born as gods of various natural world domains, including Tāwhirimātea (god of the wind), Tāne Mahuta (god of the forest),Tangaroa (god of the sea) and others. Humanity is viewed to share the same beginnings and as such the links established are genealogical and spiritual in nature[13].

The binary nature of the relationships as established through the processes of Te Kore, are informed by a range of key cultural lores based on notions of balance, utu (reciprocity), mana, tapu/noa, mauri and waiora[13].

5.3 Climate risks to Māori

Within the Bay of Plenty, several marae, wāhi tapu and communities have already experienced the impacts of climate change. Examples include:

- the exposure of a sacred burial site (urupā) at Maketu from extreme weather and extensive rainfall,
- the dislodgement of a marae roof at Waiōhau due to high winds,
- and the ongoing issues posed by sea level rise, which are threatening marae in the Tauranga Moana area.

Climate change is likely to have significant impacts on Māori. Within all hui and workshops undertaken through this project, a common theme arose, that identified Māori as kaitiaki (guardians) of the whenua, who will therefore be impacted by risks posed to the natural environment to which they have an innate connection. It was also highlighted that climate change is likely to exacerbate existing inequities/ vulnerabilities within communities in the Bay of Plenty. Climate change is highly likely to disproportionately impact Māori given current income levels, poor health statistics and unemployment levels.

A national assessment of climate risks to Māori was carried out recently in **He huringa āhuarangi, he huringa ao: a changing climate, a changing world**[14]. Within this, the Huringa Āhuarangi Kaupapa Framework provides key themes through which to explore climate and Māori in the Bay of Plenty region (Figure 5.2). This framing has been used to organise the

[13] Marsden, S. 1975. God, Man and Universe. In (Eds.) King, M. Te Ao Hurihuri: The World Moves On. Hicks Smith: Metheun.

[14] Awatere et al., (2021) He huringa āhuarangi, he huringa ao: a changing climate, a changing world. Ngā Pae o te Māramatanga

discussion for the purposes of this report only. It is not the adopted cultural framing for the Māori within the region, as these will reside within each of the 35 iwi quarters.

The Huringa Āhuarangi Kaupapa Framework comprises of four main pou:

- He Kura Taiao (Living Treasures).
- Whakatipu Rawa (Māori Enterprise).
- He Oranga Tāngata (Healthy of People).
- Ahurea Māori (Tikanga Māori- Māori Culture, values and Principles).

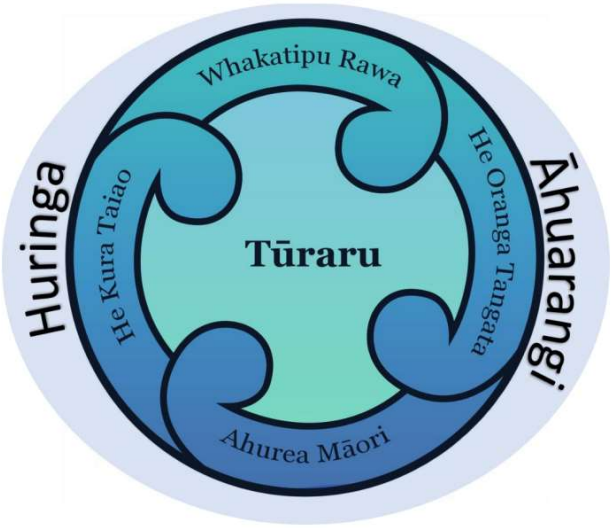

Figure 5.2: Huringa Āhuarangi Kaupapa Framework

He Kura Taiao- Living treasures

He Kura Taiao- Living Treasures represent natural ecosystems and the interconnection of everything living and non-living [14]. Climatic changes are likely to have a significant impact on the natural environment, and therefore on Māori communities and their wellbeing. Natural systems provide spiritual benefits in terms of balance, mauri, and waiora. The cultural foundations of iwi/Māori are supported by connection through whakapapa, the development of te reo me ona tikanga (Māori language and culture) and the interactions between people, the environment and the spirit world.

Many whānau, hapū and iwi rely on natural resources to provide food, wood for heating, and cultural artefacts. Food as sourced through the natural environment is also used in customary ceremonies. The processes of hunting and gathering are usually culturally centred and enable cultural values to be upheld. This includes the capacity to afford manaakitanga (care) and to support whanaungatanga (social connectedness) practices. These customary practices include rich language and histories that are inter-generationally transferred through pūrākau, whakatauākī, waiata, haka and alike. Practices are in place to protect and replenish natural resources and include kaitiakitanga (stewardship) of environmental spaces and rāhui (restrictions) that are placed on depleting resources.

Within the Bay of Plenty, the following are some key considerations relating to Māori:

- Māori have a role as Kaitiaki over the natural environment; increased risk to the natural environment places further risk to the capacity of the Kaitiaki to be responsive.
- The terrestrial ecosystems are of importance to whānau, hapū, iwi, and businesses, contributing more broadly to the health and wellbeing of the broader ecosystem[14]. This is particularly relevant within and around the extensive Māori land holdings across the region. Risks to terrestrial ecosystems are discussed in Volume 3.
- The well-being, care, utilisation, and management of freshwater ecosystems is of utmost importance to Māori. Taonga species that are likely to be impacted and that are of importance to Māori include longfin eels, lamprey (piharau, kanakana), īnanga, kōaro, banded kōkopu, the shortfin eel and the freshwater mussel[14]. Risks to

freshwater ecosystems are discussed in **Volume 3:** Ecosystems: Freshwater.

- Warming seas and land surface temperatures are directly impacting species such as snapper, kōura, pāua and hoki that are important to Māori, and ocean acidification is likely to impact kina and mussels. Decline of these species will impact Māori commercial interests and Māori cultural values and customary practices. Risks to marine ecosystems are discussed in **Volume 3:** Ecosystems: Coastal and marine and risks to fisheries are discussed in **Volume 3:** Economic industries: Fisheries.

Whakatipu Rawa- Māori enterprise

Māori enterprise relates to the Māori economy, which includes Māori post-settlement governance entities, Māori land trusts and incorporations and Māori self-employed businesses engaged in trade and exchange. The main areas that Māori businesses occupy at a national scale include the service industry, and natural resources (agriculture, horticulture, farming, fishing and forestry and manufacturing[12]. Approximately one third of New Zealand's Māori economy sits within the Bay of Plenty, primarily across the agriculture, horticulture and forestry industries (Toi Kai Rawa, 2021).

The strong presence of Māori within the primary industry sector of the Bay of Plenty includes investment in the kiwifruit industry. This amounts to $220 million, comprising 10% value of the total[12]. Māori investment in aquaculture and fisheries is also prevalent throughout the region, with Te Waiariki Iwi Aquaculture, Ngāti Tūwharetoa Fisheries Charitable Trust, and Whakatōhea Mussels (Ōpōtiki) Ltd, to name a few. These industries are providing not only economic growth within Māori communities, but also job opportunities, which puts the environment at the forefront (Porter, 2020). Most of Māori fishery investment is in four key species: kōura (rock lobster), pāua, snapper and hoki[15].

Within the Bay of Plenty, key considerations relating to the impacts of climate change on Māori enterprise include:

- Warming seas and land surface temperatures are directly impacting marine environments and species such as snapper, kōura, pāua and hoki that are important to Māori. Ocean acidification is likely to impact kina and mussels that are an important food source. Decline of these species will impact Māori commercial fisheries and aquaculture interests and Māori cultural values and customary practices. Risks to marine ecosystems are discussed in **Volume 3:** Ecosystems: Coastal and marine and risks to fisheries are discussed in **Volume 3:** Economic industries: Fisheries.
- Māori have significant commercial investments in many primary industries. These include in honeybee production from pōhutukawa and mānuka, which are likely to be impacted by climate change[14]. Other commercial interests include kiwifruit, pine forests, and dairy farming. Risks to these are discussed in **Volume 3:** Economic industries: Horticulture, **Volume 3:** Economic industries: Forestry, and **Volume 3:** Economic industries: Agriculture respectively.

He Oranga Tāngata – Healthy people

He Oranga Tāngata represents the health of Māori people. A Māori worldview of health and wellbeing extends beyond physical interpretations, to include a broader holistic view that incorporates intellectual, physical, social, and emotional dimensions[16]. Māori are likely to be disproportionality affected by climate-related health impacts, due

[15] Reid J, Rout M, Mika JP 2019. Mapping the Māori marine economy. Wellington, New Zealand: Sustainable Seas National Science Challenge, 108 p

[16] Pere. R. 1991. Ao Ako. Global Learning. New Zealand.

to the underlying disparities that currently exist within the health system of New Zealand[14].

Health inequities are complex and include a range of factors, that continue to reinforce existing inequities. Past inequities created through a dispossession of land, destabilisation of cultural foundations, and social, economic and political marginalisation is argued to contribute to the health and wellbeing of Māori today[17]. Additionally, various contemporary factors that influence geographical location, demographics, socio-economic status, current health burdens, health system capability and capacity to adapt add to the inequities for Māori[17].

Social and economic conditions, such as lower levels of income and social conditions in many cases contribute to lower levels of health[17]. Māori in comparison to their non-Māori counterparts have relatively higher representation within the deprivation classification[18], as well as higher morbidity and mortality rates. For example, life expectancy for Māori is seven years lower than that of non-Māori counterparts. Māori also have significantly higher rates of most major diseases, such as cardiovascular disease, cancers, chronic respiratory diseases, and diabetes[17].

Within the Bay of Plenty, key risks from climate change on Māori health include[17]:

- Direct links between people and the environment are culturally significant for Māoriand climate impacts on the environment may impact Māori wellbeing.
- Potential climate related impacts on Māori enterprise may impact whānau, hapū, and iwi through increased stress and mental health issues for business owners. It may also lead to increasing poverty levels with associated poor health outcomes due to reduced levels of employment opportunity, decreased household income levels, and financial security of iwi businesses and corporations.
- Climate impacts on primary industries and the environment may increase the cost of food and compromise food security. This may drive nutrition deficiency in communities with lower incomes.
- Extreme heat conditions may impact suffers of chronic diseases, of which Māori are overrepresented[14]. Temperature may also pose increasing health risks to outdoor workers; just over 20% of Māori in the Bay of Plenty work as labourers.
- Increasing temperatures may contribute to the establishment of vector-borne and zoonotic diseases. Coastal Māori communities in Bay of Plenty region may be particularly vulnerable, as well as the many rural marae that have unreticulated water supplies.

Ahurea Māori, Tikanga Māori - Māori Culture and Practises

Ahurea Māori, refers to Māori culture and practices including *te reo me ona tikanga*. This is represented in typology of the land, the histories associated with settlements, of war, of celebration, of cultural ceremonies and of spaces where ancestors rest. The environment is also a source of food, a space where healing plants can be located, where wood for fire is gathered, where work occurs and where recreational activities take place. The star system Matariki provides insights into the planting and harvesting of crops, whilst nature provides insights into when certain foods are ready for harvesting.

Mana whenua have an inter-generational history in relation to place. This is represented in te reo me ona tikanga, where narratives, whakataukī, waiata, mōteatea and haka express past events, food and resources, marriages, plight and much more. The place-based foundation of culture

[17] Jones, R., Bennett, H., Keating, G., Blaiklock, A. 2014. Climate Change and the Right to Health for Māori in Aotearoa/New Zealand in Health and Human Rights Journal, 16,1.

[18] Bay of Plenty District Health Board Annual Report 2020 https://www.bopdhb.health.nz/media/uuhb1nlu/bopdhb-annual-report-2020.pdf

is represented in the cultural reference points for different iwi, including sayings, expressions, mōteatea, haka, waiata and environmental references to history. Matāuranga-ā-hapū as a cultural body of knowledge is based on place based historical encounters including the associated tikanga that informs practice.

Climate related damage, modification and/or loss of cultural locations and features, will impact Māori within the region in a range of ways including[14]:

- Reduced ability to undertake customary practises (tikanga) with consequential impacts on spiritual and physical wellbeing.
- Risk to intergenerational knowledge (te reo me ona tikanga), whakapapa (genealogy), tribal histories and narratives that are linked to the environment.
- Impacts to the perpetuity of te reo me ona tikanga (language & customs and protocols), and mātauranga Māori (cultural knowledge). As a result, social cohesion and wellbeing may be adversely affected.
- Loss of taonga species and the capacity to engage in cultural ways with the environment whether through the gathering of rongoā and/or kai impacts the extent to which people can engage in traditional practices.
- Culturally significant environmental places are at risk including for example wāhi tapu, traditional astronomical sites, traditional wananga and traditional burial sites. Locations of these are mapped in Figure 5.3, with many located near the coast or close to waterways. The majority of marae, especially in the Western Bay of Plenty, are low lying and exposed to climate change impacts. Traditionally Māori would not have permanent settlements so close to the water and preferred higher ground. Many of these low lying marae now exist because of the marginal land many iwi were left with post confiscation. Damage or loss of marae has importance as these act as ancestral meeting houses and represent more than just a physical building. They are the physical embodiment of the connection between Māori and Papatūānuku (Bailey-Winiata, 2021). Marae are the setting for tangihanga (funerals), and celebrations and hui (meeting). Marae are also the central hub of many Māori communities, they include tikanga practices that inform community leadership, and provide established support mechanisms and resources that many whānau rely on. Damage and strain on these social structures through climate events will have cascading impacts on the extent to which communities can remain socially connected and supported.

5.4 Case studies

Case studies of Maketu and Waiōhau marae within the Bay of Plenty are documented to provide an illustration of what climate risk may mean to Māori communities. These outline the main climate risks to those specific hapū/whānau and provide context on what this means to their communities. Further detail on the Waiōhau case study is included in Appendix C.

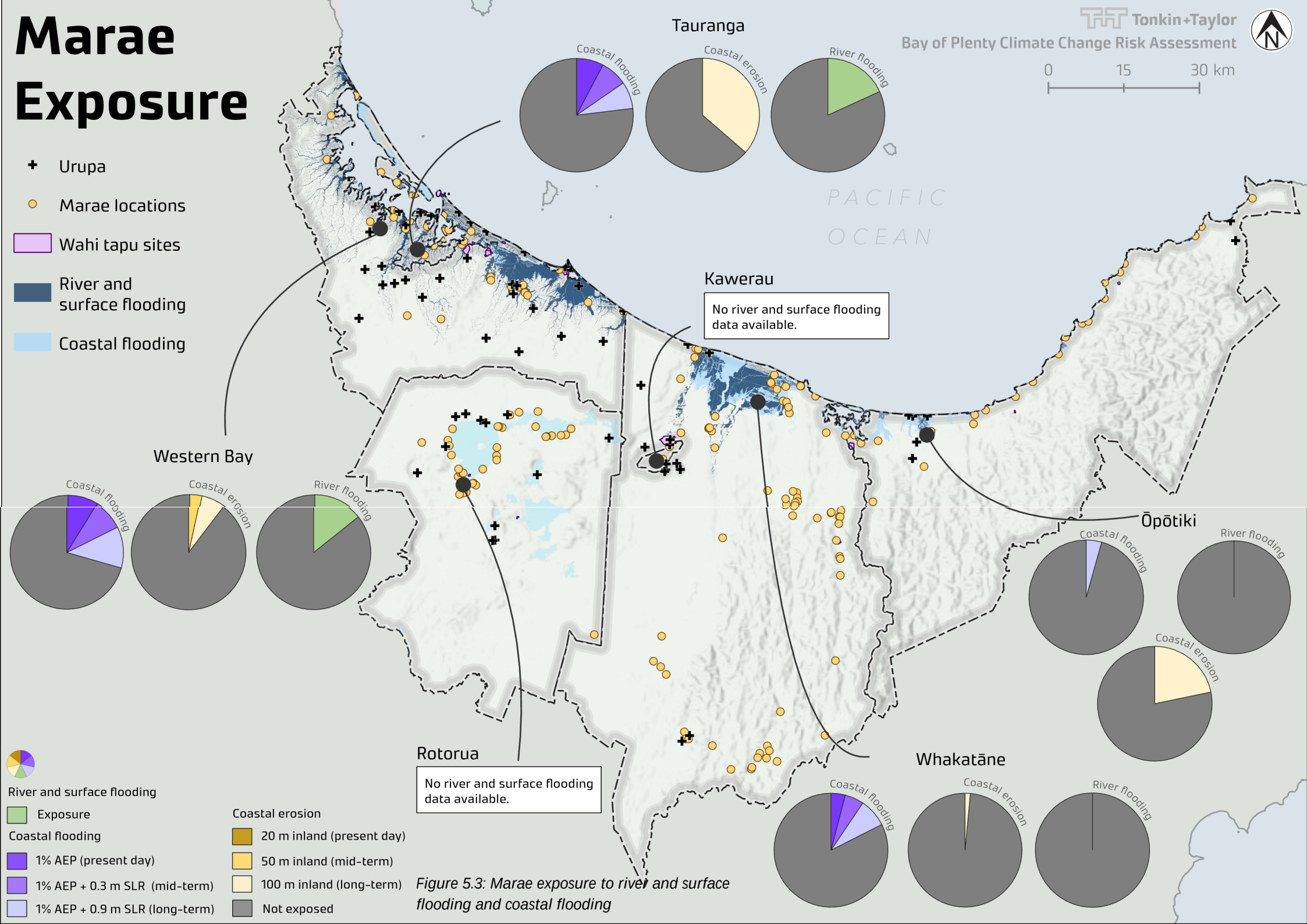

Figure 5.3: Marae exposure to river and surface flooding and coastal flooding

HE TOKA TŪ MOANA MŌ MAKETU
Maketu Climate Change Adaptation Plan

Maketu is a small coastal town located on the shore of the Maketu Estuary, with a population of 1,197 people, that can more than double over summer. Whakaue Marae of Maketu is a key coastal marae for the Te Arawa iwi, as it honours the landing place of their ancestral waka. In the face of increasing coastal hazards, the haukainga (iwi who reside at Maketu) along with the Maketu community have developed **He Toka Tū Moana mō Maketu: The Maketu Climate Change Adaptation Plan.**

In recent years, the Maketu community has seen more frequent coastal flooding, including near Whakaue Marae, following subtropical storms. In 2019, large swells caused a landslide, causing koiwi (human remains) to tumble from the clifftop urupā at Ōkurei to the beach below.

The climate change adaptation plan identifies climate risks to the community including:
- More frequent and intense storm events causing coastal erosion and inundation.
- Rising sea levels causing flooding of low lying areas.
- More frequent heat waves and drought events.
- Changes to habitats and ecosystems for our taonga bird, fish, and shellfish species.

The community identify that climate change may impact all aspects of their lives and all parts of the community, including:
- Homes, businesses, community facilities and productive land, particularly in low lying areas.
- Cultural infrastructure, particularly Whakaue marae, coastal urupā, cultural heritage sites and mahinga kai.
- Cultural practices and knowledge.
- Built infrastructure, particularly stormwater and wastewater.
- Coastal, freshwater and land-based biodiversity.
- The health, security and wellbeing of their community.

They identify that their elderly and young will be particularly impacted by climate change. Providing a safe, liveable community for the generations to come is at the forefront of their efforts. The collective vision of the community is:

Me Toka Tū Tonu Tātou: The Maketu community is prepared for, can adapt, and will be resilient to a changing climate.

The Whakaue Marae community sees themselves selves as *Tokaparore; the sacred rock to which their ancestral waka was tethered.*

Their vision is to be strong and steadfast against the tides of change and uncertainty (climate change). They believe that everyone has a role to play in responding to Climate Change. For them, climate change adaptation means modifying their way of life and doing things to reduce the impacts of climate change on their people, taiao (environment), and special places.

He Toka Tū Moana mō Maketu enables the community to begin planning for a future that may look and be different to what they are used to at the present. The Plan will be used for the community to proactively work together to take practical action with, and for the community. This action includes:
- 12 Priority Projects and 7 Enabling Actions as outlined in the Plan, to focus climate change adaptation efforts
- Highlighting the aspirations and actions of the community to others (e.g., agencies and stakeholders) and influencing their decisions (policies, projects, funding).
- Supporting applications for funding to deliver our priority projects.

He Toka Tū Moana mō Maketu: The Maketu Climate Change Adaptation Plan is available online here.

Whakaue Marae

Waiōhau Whanāu Reflections: Climate Change Summary of a climate risk workshop November 2022

Waiōhau is a rural valley situated north of Murupara and south of Lake Matahina. The Waiōhau lands adjoin the eastern side of Rangitaiki river in the north-western part of the Urewera district. The hapū of Ngāti Haka-Patuheuheu are known for their occupation within this area, and are connected to Waiōhau marae. This hapū are a part of Ngai Tūhoe, which has ancestral connections to broader land mass Te Urewera, the mountain Hikurangi and the awa Rangitaiki.

A workshop was conducted at Waiōhau marae with community members to discuss climate change and the risks this may pose to the valley. The workshop featured local narratives of the valley and their experiences, observations and views in relation to climate risk. A full documentation of this workshop is included in Appendix C.

For Waiōhau whānau, understanding climate risk, climate adaptation and planning is concerned with reconciling the socio-historical factors that have contributed to the socio-cultural fabric of the community today. The hapū refer to the whakatauaki: *Ka mua, ka muri*

This refers to the importance of the past in negotiating the future. Adaptation for Waiōhau sits within this broader context.

In discussing climate risks, the Waiōhau whanāu centred discussions in relation to kai and water security. From this perspective, whenua, awa, ngahere and the health and wellbeing of the whanāu were discussed.

Reflections were that there have been significant changes to the environment, where the seasons were no longer as well defined, and frosts were occurring late into spring and early summer. Notably, there were long hot/dry spells and wetter/colder winter months. Flooding in 2004/17 blocked access out of the valley at one end due to road damage, caused damage to whenua and made access difficult for homeowners. Access to medical supplies, resources and food were the main concerns during this time.

The risks discussed by the Waiōhau whanāu during the workshop are summarised in two tables: risks to the community, and to the people and environment.

Table 1: Climate risks to the Waiōhau marae community

Climate Risk Area	Climate Risk Description
Treaty of Waitangi	Waiōhau is at risk to external central and local government policies and processes that limit and/or fail to uphold the Treaty of Waitangi due to climate change, causing further social, economic, cultural, spiritual, and environmental disruptions to the lives of Waiōhau community.
Exacerbation of inequities	Current inequities as faced by Waiōhau community are likely to be exacerbated, including their economic, social, cultural, spiritual, and environmental wellbeing.
Economic/ cultural stability	Economic stability is at risk due to climate change disruption to employment and further inequities for those that are currently unemployed. This includes damage and loss of productivity to farms/hapū owned lands that contribute to the economic capacity of the hapū and potential disruption of access to work outside the valley.
Insurability	On-going flooding and increased wildfire may cause the community to be uninsurable.
Social and educational mobility	The community capacity to develop and implement inter-generational upskilling is at risk from climate change, causing disruptions to their capacity to meet basic needs such as income, food, and resources.
Tools, data, information, and technology	The community need support to access tools, data, information, and to have access to the technology – in order to increase capacity and capability within the whanāu.
Climate risks to the eight mauri elements of Te Umutaoroa	The eight mauri elements of Te Umutaoroa are relevant across all risks identified - as informed by an understanding of the complex matrix of relationships between people, the environment and spirituality. To this end, all is connected. It is based on the Te Umutaoroa framework developed by Te Kooti Arikirangi in 1886. Refer Appendix C.

Table 2: Climate risks to the Waiōhau people and environment

Climate Risk Area	Climate Risk Description
Safety	Waiōhau community is located near a large pine forest. The community is at risk due to wildfire causing risk to the safety of their homes, whenua, wāhi tapu, urupa and hapori.
Kainga/Buildings/ marae	Waiōhau community rely on kāinga/buildings that are climate ready to face hot/dry conditions and cold/wet winter months. The community report that not all homes/buildings are climate ready and may be damaged by climate hazards.
Risk to health and wellbeing (respiratory)	Pollen drifts have significantly increased. The respiratory health and wellbeing of the people of Ngāti Haka Patuheuheu is at risk due to extreme climate conditions which causes illness.
Infrastructure: Roads, communications	Waiōhau has a single road, with entry and exit at either ends of the valley. The safety and wellbeing of the people is at risk due to flood and landslide damage to roads and communications preventing access to medical care, food and other supplies, emergency services, and access to outside employment. Loss of communications risks the cultural ways of operating such as whanaungatanga, manaakitanga, etc
Mahinga Kai & Mara kai	The bush, river and land are a source of traditional food for the people of Waiōhau. Mahinga kai & Mara kai is at risk due to extreme weather conditions causing disruption to traditional food sources, including mara kai/orchards, food forests, tuna/trout, traditional bush food such as aruhe, karaka berries, wild pigs, tuna etc
Risk to rongoa/healing	Rongoa grows in the bush area and is reliant on a stable eco-system. Loss of Rongoa may create a risk to traditional healing practices and to matāuranga-ā-hapū
Risk to matāuranga-a-hapū Traditional knowledge	Embedded in the environment are key cultural indicators that inform planting, early warning of severe weather events, this is at risk from the changing climate causing disruption to people and their ways of knowing and being
Risk to turangawaewae Place of standing	Tūrangawaewae is at risk due to extreme weather events, including extreme flooding and wildfire which causes risk to the cultural foundation and cultural footprint of the whanāu.
Risk to river health	River health is at risk due to extreme flooding (e.g. causing excessive run-off from the forest), drought conditions causing disruption to river eco-system life, increasing pest species.
Risk to spring water	Waiōhau marae is reliant on the spring water table for cooking and other uses. Reports of slime present in the water during the summer months indicates an imbalance in the water system. Springwater table is at risk due to climate change causing an imbalance in the water systems off-set by other environmental factors.
Risk to plant/forest/river species caused by predator species	Increasing temperatures may contribute to increasing pest species. For example, hornets and wasps have increased significantly in the valley. Warmer conditions may cause disruptions to the eco-system.
Risk to waahi tapu, cultural places of significance	Waahi tapu and places of cultural significance are at risk due to climate change causing damage to cultural sites of significance. For example, the waterfall near the community is an identified culturally significant space. The community report that the waterfall 'trickles' in comparison to former times when there was a steady flow.
Risk to soil health	Whenua health is at risk from extreme flooding conditions causing leeching and run-off from the pine forest that borders the community. The soil health is at risk due to flooding causing extensive run off and impacting soil health
Taonga species	Taonga species include plants, birds, fish, and all species that are considered traditional to NZ (kereru, kiwi, tui, native plants etc). Some taonga species are also considered endangered and/or near extinction. Taonga species are at risk from climate change due to extensive flooding, drought and wildfire causing declining population growth

6 Regional consequences and interactions

The interrelated and cascading nature of climate risk means that consequences of the risks summarised in Section 4 will affect all aspects of the region. A range of these consequences are identified that relate to direct risks to specific sectors (Volume 3). Consequences to sectors are summarised in the table below in relation to the four wellbeings: social, environmental, economic and cultural (see Appendix A – Methodology for wellbeing definitions).

Table 5.1: Summary of regional consequences for the Bay of Plenty

Ecosystems

Sector	Social	Environmental	Economic	Cultural
Ecosystems	• Loss of indigenous species, ecosystems and biodiversity may impact community wellbeing and cause a loss of sense of place. • Loss of ecosystems will also impact amenity, recreational use and tourism opportunities	• Climate effects on multiple native species and ecosystems will likely have a cumulative and potentially cascading impact, and many species have potential to become regionally extinct and more populations endangered.	• Reduced ecosystem functionality may have economic impacts on farmers, land-owners and the forestry sector. • Loss of amenity and tourism opportunities for recreational users (fishers, hikers, etc.) with resultant impacts on livelihoods and the economy.	• Loss of taonga species and biodiversity has impacts on cultural identity for Māori. Reduced ability to gather mahinga kai, threatening wider food security. • Loss of taonga species also impacts health, specifically traditional Māori medicine and use of plants (Rongoā), and cultural practices such as raranga (weaving).

Infrastructure and services

Sector	Social	Environmental	Economic	Cultural
Transport infrastructure	• Safety risks along with reduced accessibility to communities, including disruption to critical routes for emergency services Loss of access to beaches and other sites causing reduced amenity. • Disruption to supply chains resulting in economic impacts, with flow on effects to the wider community.	• Sediment and contaminants in runoff from roads can cause environmental damage.	• Increased maintenance costs and cost of repair. Loss of access causing impacts on the local economy Supply chain disruption can disrupt regional activity and freight, having a range of downstream economic implications.	• Loss or disruption of access to cultural sites and communities (many marae act as emergency shelters).
Energy & Telecommunications	• Drought may create increasing tension regarding the allocation and prioritisation of water use. • Disruptions to communications can lead to a wide range of community and social implications, including emergency response efforts. • Loss of power can result in disruption to critical infrastructure and facilities (e.g. water, wastewater, communications, healthcare) and can disruption food supply chains.	• Increasing demand for water for commercial uses (e.g. for agriculture, or to generate electricity) may have adverse impacts on the environment if low flow thresholds are not met.	• Economic loss if communication is unavailable, or if energy supplies are interrupted. • Loss in productivity.	• Many marae act as emergency shelters and may be impacted by power and communications outages.
Waste	• Environmental contamination may cause a loss of amenity and have consequential impacts on mental health. • Release of toxic gasses (for example during fire) may be hazardous to public health. • Disruption of services may impact community wellbeing.	• Environmental contamination may damage indigenous biodiversity, water quality and coastal ecosystems.	• Environmental contamination may result in abatement notices and fines, further increasing costs of operation. • Increased damage and disruption to waste management facilities may result in rising costs, as will investment in adaptation measures.	• Environmental contamination may impact cultural values.

Sector	• Social	• Environmental	• Economic	• Cultural
Water management and infrastructure	• Poor water management can lead to reduced natural amenity, impacting on people's enjoyment and use of natural areas. • Lack of water can affect human health, habitation and general sanitation and hygiene. • Water scarcity can create tensions between competing demands and lead to inequitable allocation decisions. • Increased flooding can lead to severe impacts on communities when homes and livelihoods are impacted by flooding, causing stress and long term impacts on mental health. • Inundation of wastewater systems can lead to effluent discharge which can impact on community wellbeing and health. Wastewater odour can also impact community health.	• Degraded health of waterways and reduced water availability can result in a wider loss of biodiversity. • Extreme events can cause wastewater overflows into receiving environments, that can impact on ecosystems. Flood damage can also generate large volumes of runoff / debris and cause contamination. • Flood protection and drainage schemes can impact water flows into wetlands, inhibiting them to drain/function properly.	• Increased costs to source and treat water can result in impacts on the wider economy. Reduced water availability, disruption of supply and flooding results in loss of productivity, causing economic losses. • Reduced natural amenity can impact on tourism. • Increased costs of operation (e.g. pumping), maintenance, and capital expenditure required to cope with a changing climate and to adapt. • Maintaining existing service levels may require increasing the level of investment, which may become unaffordable Direct and indirect flood damage may cause significant financial implications and impact ability to access insurance.	• Reduced water availability and quality will compromise food sources / kaimoana and may have wider impacts on cultural identity. • Contamination of the environment from wastewater has potential for significant cultural impacts

Economic industries

Sector	Social	Environmental	Economic	Cultural
Primary industries	• Uncertainty and stress around changing climate hazards and their impacts on the primary sector, livelihoods etc (mental health impacts). • Competing land uses needing access to water can create tension within communities. • Scarcity of water may result in reduced produce availability, which can impact wider economy and community. • Reduced food security can lead to further inequity as food prices may rise.	• Increasing demand for water for primary sector may result in negative environmental outcomes. • Increasing soil loss and erosion may cause damage to waterways and harbours. Similarly increasing levels of high-nutrient runoff may also impact receiving environments. • Increased risks to worker health and safety due to temperature extremes. • Potential for increased use of chemicals in response to a changing climate which may impact workers (and may also have environmental impacts). • Impacts from increase in forest fires: ecological damage, water quality impacts, increased sediment/ash within stormwater runoff, more erosion, more atmospheric particulates (health and climate risks).	• Increasing costs due to: acute and chronic events, adaptation costs (e.g. physical protection, relocation), changing climate mitigation and environmental standards, increased need for pesticides and other chemical applications, and rising insurance premiums. • Also, loss of income due to reduced productivity and quality of produce. • These drivers may reduce viability for some producers resulting in economic and employment impacts. Increased costs of produce will have consequential consumer price increases and social impacts.	• Cultural identity can be impacted, particularly if complete ecosystems or native species are damaged/lost. • Traditional food gathering may be impacted which could lead food scarcity and result in further inequities • Impacts on Māori enterprises in agriculture, horticulture, aquaculture and forestry. • Impacts to kaimoana can affect cultural identity and .
Tourism	• Loss of tourist activities may impact mental health and wellbeing		• Loss of tourism can have wider impacts on the economy and employment, and can impact people's livelihoods	• Impacts on tourism may have a high impact on Māori as cultural tourism is a major attraction within Rotorua.

6.1 Interdependencies

The impacts and consequences of climate change often create interdependencies across sectors and wellbeings. These interactions can cause sequences of events, which can propagate as cascades, causing unforeseen or far-reaching impacts. These cascades can span geographies and stretch over various time scales. Considering these interdependencies can help to consider climate risk from a holistic perspective.

Example of interdependencies that can influence climate risk are shown in Figure 6.1. This diagram shows that a risk to water resources could, in turn, impact ecosystem health, disaster risk management, agricultural production, and potable water supplies within cities. These impacts can then influence health and wellbeing of people and communities.

Within the Bay of Plenty, the identified risks can propagate through the region's ecosystems, economy, and community health and wellbeing, in a wide variety of ways.

An example would be the impact of drought or extreme temperatures on agricultural production (such as kiwifruit) with consequences of reduced economic productivity for producers, the need to invest more costly adaptation actions (e.g. water imports, higher usage of chemicals), potential food insecurity for communities, and broader economic impacts arising for local communities as a result.

Ecosystems

Climate change poses risks to freshwater, marine and terrestrial ecosystems. The interconnectedness and complexity of natural systems means that these risks can emerge and propagate in many different and unpredictable ways.

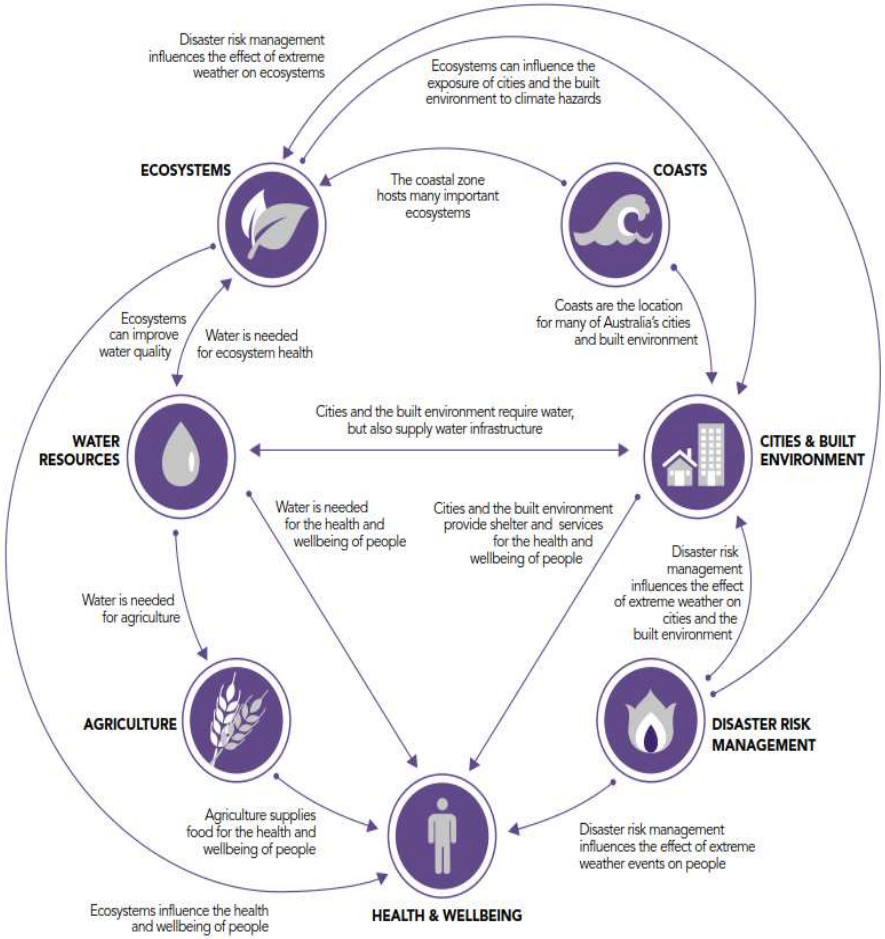

Figure 6.1: Example of interdependancies and cascades that can influence climate risk[19]

[19] Australian National Climate Resilience and Adaptation Strategy, 2015

Impacts can result in damage, reduction or complete loss of ecosystems. These impacts can also be exacerbated by other pressures – such as land use, land use change, resource depletion, pollution, etc.

Both freshwater and marine ecosystems are at risk from worsening water quality, that has potential to arise due to the interrelated impacts of increasing runoff (from a range of sources e.g., increased erosion, washouts and landslides, nutrient leaching, agricultural runoff from farms), increased extreme temperatures, and reduced flows during droughts. This can lead to algal blooms and eutrophication, and in turn, damage ecosystems and key species.

Reduced water availability can result through drought, and over-abstraction and allocation. This can have consequences for biodiversity, water quality, primary industries, tourism, and energy generation, and can result in impacts on cultural practices, communities and the economy. Lack of water can affect human habitation and general sanitation and hygiene, and can lead to health impacts in people.

Community & cultural wellbeing and social cohesion

Social inequities and vulnerabilities are at risk of being exacerbated due to increasing health impacts, economic costs, disruption to communities, loss of employment, loss of natural resources and many other climate related impacts. As discussed in Section 3, measures of social deprivation indicate a wide spread across the region, with higher deprivation within the eastern Bay of Plenty areas. Māori communities are also likely to be disproportionately affected, given income levels, poor health statistics and unemployment levels.

Temporary or permanent displacement of communities can occur from a range of climate hazards and is likely to become more frequent with increasing intensity of storms and coastal flooding events. Increasing disruption to key transport routes to remote communities will increase the occurrence of these communities being cut off and isolated.

As outlined in Section 5, the impacts of climate change, particularly on the natural environment, can have significant implications for Māori and their cultural identity. Climate change may cause risks to kaitiakitanga (stewardship), kotahitanga (unity, connection, community 'togetherness', transmission of knowledge), manaakitanga (care) and mahinga kai (such as tuna, eels and watercress).

The amenity of the region may be degraded as the result of a range of risks, including: coastal erosion which can degrade beaches and restrict access to the coast, loss or damage of indigenous ecosystems and reduced water quality. This can lead to a loss in connectedness to the natural environment and a loss of recreational areas, contributing to overall decline of wellbeing.

Increasing coastal hazards may drive re-settlement within the region as people are required to move away from exposed areas. Conversely, inward migration may occur as people from outside the region (from other climate exposed locations) come into the region to settle. Changes to climate and tourism patterns in other areas (e.g. reduced snow fall on Mount Ruapehu) could put strain on communities as tourism modes shift to adapt to the climate.

Climate migration may result in changing demographics and place increasing pressure on existing communities. Over time, it is possible that without suitable planning, the region’s capacity to support communities with adequate infrastructure, housing, health care and social services may be put under pressure.

Food security may be put at risk due to reduced food production related to water availability, changing growing conditions, and increasing pests and diseases. This could be exacerbated by disruption to transport routes impacting produce supply chains, both in and out of the region. This could also impact producer income and costs of living.

Increased occurrences of emergencies such as wildfire, flooding and extreme weather will place an increased pressure on the capacity of

emergency services. These events also have the potential to increase insurance costs, which can have widespread implications for communities.

Many marae are located in remote and exposed locations and may experience increasing damage from climate hazards, and become increasingly isolated as access routes are disrupted by landslides, flooding and extreme weather. This damage and disruption may compound climate risks to these communities, as marae are often used as emergency shelters.

Local economy

Impacts may arise from a loss of productivity across all primary industries and tourism, with related impacts on employment. Gradual onset hazards and climate-related disasters can lead to a range of direct and indirect costs relating to increased maintenance and operational costs, repair of damages, and implementation of preventative or adaptive measures. This will be a particular challenge for district councils and other organisations with high levels of property and asset ownership.

Climate change impacts on businesses and industries will have flow on effects on employment and livelihoods of people within the Bay of Plenty. This will be most severely felt by small local businesses and those in industries that are closely tied to the natural environment such as tourism and primary industries, which includes a significant proportion of Māori enterprises. This can have implications for livelihoods, incomes and people's mental health, and can exacerbate existing inequities.

The availability of insurance and changing premiums are likely to change as a result of climate change, particularly for assets that are located within exposed areas e.g. close proximity to the coast and floodplains. This could be a particular challenge for marae that are used as emergency centres.

The cost of living is likely to increase as climate risks result in economic impacts including supply chain disruption, insurance, repairs of damages and adaptation measures. This can lead to further exacerbation of inequities within communities.

Health

Climate related health impacts are wide ranging and can arise from a range of inter-related factors such as worsening water availability and quality, temperature related and vector-borne diseases, food supply interruption, air quality deterioration, and lifestyle and behavioural changes. Indirect impacts on health are mediated by a complex interaction of social, environmental, and economic factors. Figure 6.2 illustrates a range of direct and indirect impacts.

Figure 6.2: Impacts of climate change on human health (source: te Whatu Ora, 2022)

Health risks can propagate through multiple impact pathways and cascades. As illustrated in Figure 6.3, increasing temperature can lead to a change in food production, changes in food costs, changes to consumption patterns and consequential diet and health impacts.

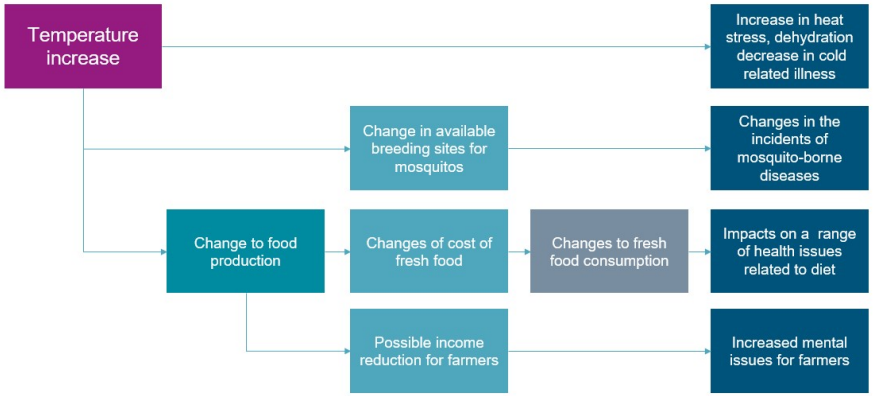

Figure 6.3: Temperature-related impact pathways on health

Mental health impacts may arise from a range of climate change related factors, including trauma following extreme events (such as floods or storms), environmental degradation, displacement of community and culture, loss of livelihood, reduced personal autonomy, and anxiety relating to the occurrence of climate change.

The level of risk is dependent on a range of complex factors, including exposure of people, infrastructure, and environment; and demographics including age, income, education, livelihood, housing type, social networks, and cultural relationships. The occurrence of mental health impacts is strongly linked to socio-economic factors.

Climate change is likely to exacerbate existing inequities/ vulnerabilities within communities in the Bay of Plenty. Vulnerable populations include socio-economically deprived communities (refer Section 3), children aged 0-4 years, older adults aged 85+, and people working in primary industries. Climate change is also highly likely to disproportionately impact Māori given current income levels, poor health statistics and unemployment levels, and geographical locations (as discussed in Section 5). There are many socio-economically deprived areas within the Bay of Plenty, that are exposed to climate-related hazards such as coastal erosion and flooding (refer). Generally, these locations have poor accessibility and ability to respond to natural disasters (i.e., lower income levels poor access to transport, lack of reserve food supplies, inequitable distribution of infrastructure etc.), therefore increasing their vulnerability. Lack of resourcing was also found to be a contributing factor to these existing inequities, reducing the ability of these communities to prepare and/or respond.

Risks to health may also place increasing pressure on health related services, resulting in the following service delivery risks:

- Increased presentations/ demand for hospital-based services
- Increased demand/stress on staff (mental and physical health)
- Reduced quality/level of service
- Reduced ability to access care by the community
- Reduced ability to access healthcare sites for workers
- Increased demand for emergency services
- Supply chain issues
- Increased demand on facilities/services/sectors
- Increased demand for mental health services
- Increased demand for public health services, particularly during a response to climate-related events.

7 Where to next

The Bay of Plenty Climate Change Risk Assessment provides a regional overview of current and future climate risks in order to identify and highlight areas where a focused effort is needed to manage these risks.

The project has generated a significant body of information, providing a platform for adaptation planning and response throughout the region at a range of scales and by a range of parties. The outputs from this assessment establish a common baseline of climate risk for the region and are available for all to use: businesses, primary producers, communities, iwi/Māori, researchers, local government and public sector agencies.

The regional risk assessment can be used to:

- Undertake more detailed risk assessments at a range of scales. These could be focused on specific species, environments, sectors or industries, or take a district or community approach.
- Raise community awareness, to support understanding of the changing climate and enable communities to take action.
- Support the prioritisation of adaptation response and investment.
- Contribute to Aotearoa New Zealand's National Adaptation Plan goals and actions.

Specific next steps identified for each of the sectors are discussed in Volume 3.

An additional benefit of the project has been the valuable connections established between and across sectors through the risk assessment workshops and hui. These relationships will be important in taking this work forward, sharing expertise and knowledge and ensuring a coherent response to climate risks for the Bay of Plenty.

8 Applicability

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

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