

Bay of Plenty Regional Climate Change Risk Assessment

Volume 3: Sector summaries

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Prepared by
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1 Introduction

This volume provides summaries of the detailed risk assessment findings for each of the following key sectors within the Bay of Plenty:

- Ecosystems: Terrestrial
- Ecosystems: Coastal and marine
- Ecosystems: Freshwater
- Water availability & quality
- Three waters infrastructure
- Flood management
- Waste management
- Transport infrastructure: Roads, walkways, and cycleways
- Transport infrastructure: Rail
- Transport infrastructure: Airports and Ports
- Energy and telecommunications
- Economic industries: Tourism
- Economic industries: Agriculture
- Economic industries: Horticulture
- Economic industries: Forestry
- Economic industries: Fisheries
- Archaeological sites
- Health

Each sector summary draws on the findings of the detailed risk assessment, which involved a series of workshops with subject matter experts. Summaries of climate risk ratings are included in tables within each section, as well as identified consequences and next steps that are relevant to that sector. Risks ratings are presented for three time horizons (present day 'now', 2050 and 2100 under RCP8.5 (or SSP5-8.5) and RCP 4.5 (or SSP2-4.5), where:

- 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.

Risks were typically rated using a qualitative approach, with risks tending to increase over time and are higher under the higher emissions scenario. Risk are rated at a district or regional scale, however there may be localised areas where risks are far higher than indicated.

A full documentation of the detailed risk assessment is included in Appendix B and includes a risk description, exposure, vulnerability and risk ratings, and notes relating to the justification for each rating.

This assessment draws on context relating to climate projections for the region (included in Volume 1), and follows the methodology described in Appendix A.

2 Ecosystems: Terrestrial

The Bay of Plenty region contains a wide range of terrestrial ecosystem types that support many species of threatened native plants and animals, such as rare wetland and wading birds, geckos and native mistletoe. In particular, vegetation adapted to geothermal conditions, frost flats, coastal dune-lands and forests, moderate elevation hill-country, and native and exotic forests and shrublands.

The highest rated risks identified for terrestrial ecosystems relate to increased risk of fire weather and reduced number and intensity of frost days for frost flats. Figure 2.1 shows the exposure of the natural environment from coastal flooding, coastal erosion and river flooding. Table 2.1 shows risk ratings at a regional and habitat scale.

Increased extreme rainfall and flooding

Increasing extreme rainfall events and flooding presents risks to terrestrial ecosystems, particularly low-lying forest/shrubland ecosystems (Figure 2.1). Rare ecosystem types (e.g. Totara forests) are located in floodplains. Extreme flooding and erosion could threaten mature trees, cause damage to the understory and impact on regeneration. Flooding may also damage tree species that do not like wet feet, due to extended periods of soil saturation.

Table 2.1: Climate risk ratings for terrestrial ecosystems and species

Native fauna, native flora, frost flats and terrestrial ecosystems and species						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Terrestrial ecosystems and species						
Dryness and drought	Coastal	🟡	🟡	🟡	🟠	🟠
	Inland	🟡	🟡	🟡	🟠	🟠
Extreme rainfall and flooding		🟢	🟢	🟢	🟡	🟠
Landslides and soil erosion		🟡	🟡	🟡	🟠	🟠
Increased fire weather		🟡	🟡	🟠	🟠	🔴
Native fauna						
Higher temperatures		🟢	🟡	🟡	🟠	🟠
Native flora						
Higher temperatures		🟢	🟡	🟡	🟠	🟠
Frost flats						
Reduced frost days		🟠	🟠	🟠	🔴	🔴

Landslides and soil erosion

Native forests in steep areas (e.g. Kaimai Ranges) are at risk of damage from landslides and increased soil erosion. This risk is related to a range of identified hazards including increasing temperature and drought conditions. These conditions can lead to soil moisture deficits and increasing vulnerability of surface soils to erosion, which are then mobilised during storm events. Conversely, increased saturation of soils during winter coupled with an increasing frequency of extreme rainfall events may lead to more frequent landslides on steep slopes. These conditions lead to both deterioration of terrestrial ecosystems from soil erosion, and to fragmentation of habitats during landslide events.

Temperature

Native flora and fauna are sensitive to changes in temperature. Increasing temperatures may drive increased migration of northern flora species southward. This changing species composition may see increased competition in indigenous areas and see some indigenous species becoming dominant e.g., mangroves. Increasing temperatures may increase the occurrence of invasive species, where geographically constrained ecosystems such as low growing mountainous vegetation (e.g., Mt Tauhara), herbfields, leatherwood shrublands and frost flats are particularly sensitive. These ecosystems are also sensitive due to their unique characteristics and lack of capacity to adapt. Warmer temperatures may also lead to more frequent seed-mast conditions which may favour increased viability of exotic pests. Increasing temperatures also compound other climate related stressors and tend to favour exotic species thus threatening native species that are highly sensitive to competition such as geckos & skinks.

Increasing temperature can result in heat stress related mortality of individuals and disrupt temperature sensitive life stages of fauna (notably tuatara breeding populations). Species like stag beetle and Hochstetter's frogs may become stressed under higher temperatures, and warmer temperatures may contribute to drying out of habitats, reducing food availability for birds such as kiwi (Whakatāne) and bittern.

Frost flats are extremely vulnerable to increasing temperatures, with many of the ecosystem's unique and key species specifically adapted to lower temperatures. These species have very low adaptive capacity and the loss of the climate conditions intrinsic to these ecosystems will likely lead to widespread loss of this ecosystem type.

Dryness and drought

Terrestrial ecosystems near the coast are sensitive to drought conditions which may result in loss of biodiversity and change in the coastal vegetation composition. Inland terrestrial ecosystems may exhibit range shifts of some key species, and/or contraction in the extent of key ecosystem species occurrence. Dryness and drought conditions also drive lower fruiting and seeding of vegetation leading to reduced food availability and potentially starvation of native fauna.

Increased fire weather

Terrestrial ecosystems are highly sensitive to fire. Increased occurrence of fires has the potential to cause both fragmentation of existing habitats and adversely affect native regeneration. Regeneration left unmanaged is typically dominated by fast growing invasive species rather than slow-growing natives. Increased occurrence of fires may cause biodiversity loss and potential local extinction of rare species through loss of significant proportions of populations and/or habitat loss.

Natural Environment Exposure

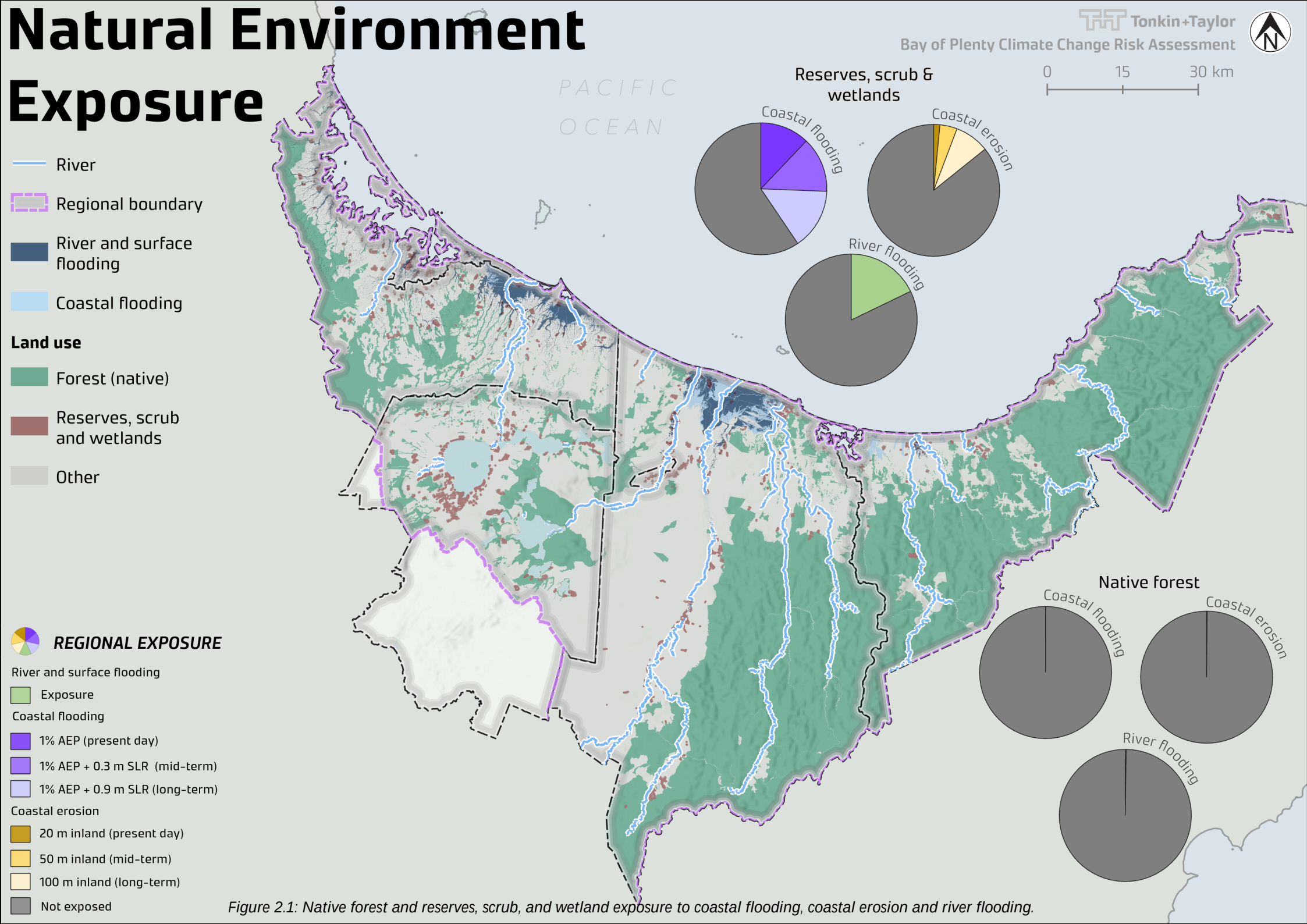


Figure 2.1: Native forest and reserves, scrub, and wetland exposure to coastal flooding, coastal erosion and river flooding.

Consequences

The loss of ecosystem functionality will have cascading and indirect effects for multiple native species and then ultimately people as summarised in Figure 2.2.

Social	Environmental	Economic	Cultural
• Loss of amenity and tourism opportunities.	• The loss of ecosystem functionality will have cascading and indirect effects for multiple native species.	• Reduced ecosystem functionality may have economic impacts on farmers, land-owners, and the forestry sector. • Loss of amenity and tourism opportunities.	• Loss of taonga species and impacts on cultural identity for Māori people. • Reduced ability to gather mahinga kai, threatening wider food security. • Economic impacts to farmers, land-owners, foresters, and loss of amenity and tourism opportunities for recreational users (fishers, hikers etc.).

Figure 2.2: Summary of consequences from climate impacts to terrestrial ecosystems

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 2.2 identifies potential next steps for relevant stakeholders.

Table 2.2: Potential next steps for terrestrial ecosystems

Element at risk	Next steps	Interested / responsible parties
Terrestrial ecosystem habitats and species	Habitat or species specific climate change risk assessments may support the development of conservation programs to support climate change adaptation.	BOPRC, Department of Conservation, Forest and Bird, Universities, and Crown Research Institutions.
Terrestrial ecosystem habitats and species	Expansion of conservation efforts may improve the ecological potential of existing pockets / corridors of habitats within and between the large forested areas that may have increased resilience to climate change e.g. Waioeka, Raukumara, Uruwera Ranges. This may improve the wider ecosystem resilience of the region.	BOPRC, Department of Conservation, Forest and Bird, landowners, local iwi & hapū.

3 Ecosystems: Coastal and marine

Coastal and marine ecosystems include the region's three harbours (Tauranga Harbour, Ōpōtiki Harbour, and Ōhiwa Harbour), many estuaries, and numerous islands. The region has a wide range of coastal habitats including estuaries, brackish water lagoons, open sandy beaches, offshore islands and an active volcano. Habitats in and around the harbours and estuaries include freshwater wetlands, saltmarsh, mangroves, seagrass, sand and mud flats, rocky reefs and tidal channels. Sand dunes line the coast from Waihī Beach to Ōpape, broken occasionally by river and harbour mouths, volcanic landforms and rocky headlands. East of Ōpape, the landscape changes to steep and rugged rocky headlands and long gravel beaches. Marine terraces are found east of Raukōkore.

The highest rated risks to coastal and marine ecosystems relate to marine heatwaves and ocean chemistry changes, sea level rise impacts on shoreline and inshore shallow marine environments, increased rainfall and flooding of near coast and intermediate marine habitats, and coastal erosion of dunes. Table 3.1 shows risk ratings at a regional scale.

Sea level rise and coastal flooding

Sea level rise and associated coastal flooding and groundwater rise may damage species and habitats within shoreline ecosystems, inshore shallow marine environments and estuarine ecosystems. Ecosystems on the coastal edge can be inundated and may have limited space to shift landward. Many species within shoreline habitats have a limited range of mobility on the coast (e.g., spiders, katipo, geckos, and skinks). Seabirds and plant species such as mangroves and saltmarsh are likely to be impacted by this 'coastal squeeze'. Sea level rise may displace these habitats or remove them entirely and threaten coastal settlements (see Section 7).

Table 3.1: Climate risk ratings for coastal and marine ecosystems

Risks to coastal and marine ecosystems						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Sea level rise and coastal flooding	Shoreline ecosystems	🟠	🟠	🟠	🔴	🔴
	Inshore shallow marine environments	🟡	🟠	🟠	🔴	🔴
	Estuarine species	🟢	🟡	🟡	🟡	🟠
Coastal erosion	Dunes	🟡	🟠	🟠	🟠	🟠
Increased extreme rainfall and flooding	General	🟡	🟠	🟠	🔴	🔴
	Near coast (<3km)	🟠	🟠	🔴	🔴	🔴
	Intermediate habitats	🟢	🟡	🟡	🟡	🟠
	Far coast (>5km)	🟢	🟢	🟢	🟡	🟡
Marine heatwaves and ocean chemistry changes		🟠	🔴	🔴	🔴	🔴
Extreme weather		🟢	🟢	🟢	🟡	🟠

Inshore shallow marine ecosystems and species may deteriorate due to impacts on key immobile species, for example increasing water depth may affect light availability to photosynthesising plants such as kelp and seagrass.

Estuarine ecosystems may experience changing salinity that could negatively impact species. Sea level rise may cause the salt wedge to shift

upstream, impacting whitebait spawning habitats, requiring them to re-establish further inland.

Coastal erosion

Coastal erosion is occurring at numerous coastal locations including Waihī Beach, Pukehina, Ohope, Hikowai, Town Point Maketū and the larger estuaries of Tauranga (smaller estuaries are more sheltered). Some sand dune systems (e.g., east of Ohope) are at risk of being replaced by shingle. Although shingle beaches can be more resilient, they can also be impacted by coastal erosion due to the release of sediment that can damage the subtidal zone. Many cliff systems are becoming increasingly eroded (e.g. Omokoroa & Matapihi), resulting in the loss of Pohutukawa and sub-canopy species on cliff lines and impacting the habitats of shag and kororā and other marine species.

Adaptation to sea level rise, flooding, and coastal erosion

The capacity of shoreline environments to migrate in response to sea level rise and increased coastal erosion is constrained by urban environments (with cleared land and high surface water runoff that can further degrade cliff faces). Loss of private properties may unlock land for coastal buffering and open up new habitats.

Increased extreme rainfall and flooding

Flood flows increase fine sediment release from land to rivers, resulting in muddy plume discharges to estuarine and coastal environments. Sedimentation is a widespread issue in nearshore and estuarine environments at present. Shallow marine environments are highly sensitive to sediment as this impacts light intensity and quality, causing 'darkening seas', which impacts all species that require light to photosynthesise. Sediment also collects on reef/rock outcrops and the sea floor, smothering marine species and habitats, including critical nursery grounds, causing a loss of biodiversity. These ecosystems tend to be degraded due to benthic trawling and are highly sensitive to further habitat degradation.

Harbour ecosystems are also impacted by freshwater pulses during flood events. Freshwater pulses can be damaging to indigenous marine species as they do not typically grow in freshwater environments. Increased flash rain events can increase stormwater discharges, that can contain a range of contaminants harmful to marine life which may accumulate in the marine sediments. In addition, rainfall events can increase faecal bacteria loads to estuaries, making swimming and kaimoana gathering unsuitable.

There is a low capacity for marine systems to adapt to sediment deposition, particularly less-mobile species in nearshore environments, and species that inhabit nearshore environments during critical life stages. Catchment and stormwater management practices can be adopted to reduce erosion and sediment/contaminant runoff into marine environments.

Extreme weather (wind and storms)

Increasing severity of storms may cause disturbance to a greater depth of the water column with large waves and swell. This may disturb sensitive biogenic reef systems, causing loss of the kelp forest canopy and mobilising shellfish beds from the sediment, causing mass shellfish mortality along beaches and shorelines.

Extreme weather, wind and storms are related to coastal erosion and extreme rainfall and flooding, with associated risks discussed in the corresponding sections above.

Marine heatwaves and ocean chemistry changes

Marine environments are highly sensitive to increasing temperatures and ocean acidification. The increasing severity and frequency of heat waves is impacting marine species and habitats. Ecological monitoring has

detected signs of severe stress attributed to warmer temperatures both in deep water environments and the intertidal zone. For example, in the subtidal habitats, monitoring of sponge species has observed signs of heat stress resulting in fungal infection and, in the shallow intertidal, increasing blooms of nuisance filamentous algae on seagrass beds.

Warming of harbours may impact many species as they are a critical habitat during vulnerable life stages, including for open ocean dwellers (e.g. Tauranga Harbour is a nursery for many fish including bluenose and dory larvae, and apex predators such as rays). Changing ocean acidity may also affect larval stages of marine species, disrupting growth, recruitment, and settlement of species such as fish, crayfish, and shellfish.

Warmer temperatures may mean conditions are favourable for new/exotic species that may damage ecosystems, particularly when the native ecosystem is under stress (e.g. increasing number of black spiny sea urchins grazing kelp forests across Bay of Plenty reef ecosystems).

The adaptive capacity of marine ecosystems to temperature increases is very low. Marine protected areas can provide resilience by promoting ecosystem health (particularly connected areas), however impacts on harbours are likely to have widespread ecological impacts, with limited ability to adapt as many key species have critical life stages that are tied to these shallow waters. Species may respond by reducing in size or through migration to cooler waters, provided receiving habitats are available to support new species.

Consequences

Consequences arising from impacts on coastal ecosystems and habitats are summarised in Figure 3.1.

Social	Environmental	Economic	Cultural
• Loss of indigenous species and ecosystems may impact community wellbeing. • Loss of amenity and recreational use of the coast e.g., fishing. • A loss of biodiversity has impacts on community and cultural identity.	• Climate effects on species and ecosystems within the region will have a cumulative impact as many species are interdependent. Effects may be compounded by climate impacts occurring in other parts of New Zealand and the world. Many species have potential to become regionally extinct and or see increasing numbers of populations endangered.	• Impacts on fisheries and coastal tourism with resultant impacts on livelihoods and the economy.	• Loss of cultural identity particularly in relation to kaimoana

Figure 3.1: Summary of consequences from climate impacts to coastal and marine ecosystems

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 3.2 identifies potential next steps for relevant stakeholders.

Table 3.2: Potential next steps for coastal and marine ecosystems

Element at risk	Next steps	Interested / responsible parties
Threatened species	Research is ongoing to monitor and further understand the impacts of climate change on key coastal and marine species. This research is important to inform adaptation responses and wider ecological protection measures.	BOPRC, Department of Conservation, Ministry for Primary Industries, Forest and Bird, University of Waikato, other universities, and Crown Research Institutions, Ministry for the Environment, local iwi & hapū.
Coastal and marine habitats	Marine and shoreline reserves are identified as being important to foster healthy ecosystems, support wider ecosystem resilience, and build resilience to invasive species. Protection, establishment and expansion of these may be an important component of adapting to climate change.	Department of Conservation, Ministry for Primary Industries, BOPRC, Ministry for the Environment, local iwi & hapū.
Nearshore environments and harbours	Sediment has severe impacts on marine ecosystems. Integrated catchment management planning (land-use planning, waterway protection, stormwater management and riparian reserves) can reduce sediment and other contaminant runoff into waterways. Expansion and extension of initiatives such as BOPRC catchment environmental plans may support adaptation.	BOPRC, Ministry for the Environment, local iwi & hapū.

4 Ecosystems: Freshwater

Freshwater ecosystems relate to the streams, rivers, and lakes of the region, and include riparian habitats and wetlands. The Bay of Plenty region has many lakes, 10 major rivers, and hundreds of other rivers, streams, and wetlands. Of the region's lakes, 18 are located in the Rotorua District.

The highest rated risks to freshwater ecosystems relate to increasing temperature, sedimentation and erosion related to extreme rainfall, drought and rainfall variability and seasonality. Table 4.1 shows risk ratings at a regional and habitat scale.

Increased extreme rainfall and flooding

Increasing frequency and intensity of rainfall is projected across the region and may drive increased erosion of catchments and sediment runoff. This can cause sediment to enter waterways, which can be problematic due to smothering of habitats, wider water quality issues, and eutrophication relating to nutrient loading associated with sediment laden runoff. High rainfall can also cause landslides and stream bank erosion, which can damage riparian habitats. Increased flooding can enable the spread of pest and weed species to downstream locations and offline / disconnected aquatic habitats. Catchment restoration projects can improve ecosystem health and attenuate catchment flows. However, improvements can be slow, and their success is often dependent on funding and community support.

Table 4.1: Climate risk ratings for freshwater ecosystems and species

Risks to freshwater ecosystems and species						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Extreme rainfall and related erosion	Lakes					
	Streams and rivers					
Temperature	Lakes					
	Streams and rivers					
Drought	Lakes					
	Streams and rivers					
Rainfall variability	Wetlands					
Landslides						
Fire weather						

Temperature

Summertime water temperatures currently exceed threshold temperatures for the health of some species (Galaxids), and many lakes. Warmer temperatures compound water quality issues, increasing the release of phosphorus and nitrogen from the sediments of lakes, and this can trigger algal blooms. Warming lake temperatures may expand the

range or population of many invasive plant and fish species. This may compound other impacts relating to increasing temperature such as increased occurrence of algal blooms. There are limited options to adapt to increasing temperatures, however catchment management practices to reduce nutrient inputs into lakes will help reduce lake sensitivity to temperature increases.

Drought

Increasing drought and low flows are likely to result in lower lake levels, low flows, or dry-out of smaller streams. Lake and stream ecosystem sensitivity is interdependent with baseline stream water quality and temperature. Low flows and warm temperatures associated with drought can result in reduced mixing of water bodies. Associated low dissolved oxygen concentration and ammonia release can trigger fish mortality or changes in species metabolism.

Temperature related impacts can be managed by increased shading through riparian planting. Converting piped stormwater networks to natural streams (‘daylighting') and associated stream restoration projects can help to provide for new habitats, improve water quality and improve overall ecosystem health.

Rainfall variability and seasonality

The sensitivity of rainfall fed wetlands to rainfall variability is dependent on the wetland source. Those that are rainfall fed are most sensitive to climatic changes, with ecosystems that may be impacted by increasing extremes. For example, long periods of submergence can lead to widespread die-off of forests and lead to riparian zone changes. Wetlands tend to have low adaptive capacity. Many wetlands have ecology that is highly specific to local chemistry, therefore species have a limited ability to relocate.

Landslides

Landslides introduce short term sediment and nutrient (particularly phosphorus) plumes into lakes, these can temporarily smother habitats. The effects of this are thought to be short term, as higher flows flush sediment deposits.

Fire weather

Fire can have devastating impacts on catchments which can cause increased rates of erosion as exposed land regenerates and can have detrimental impacts on water quality. Direct impacts on freshwater tend to be short lived, however long-term impacts can occur. For example, the Kaimaumau wetland (Northland) wildfire burned for over 6 months causing significant ecological damage. Fire risk can be reduced with measures to control flammable vegetation.

Consequences

Consequences arising from climate impacts on freshwater ecosystems are summarised in Figure 4.1.

Social	Environmental	Economic	Cultural
• A loss of biodiversity can undermine community wellbeing and degrade the local amenity causing a loss of sense of place.	• Cumulative impacts may extend to terrestrial and coastal ecosystems, and beyond. When combined with impacts across the region, many species are likely to become regionally extinct and more populations endangered.	• Amenity and tourism may be impacted by damage to freshwater ecosystems, with resulting economic impacts.	• Loss of biodiversity and degradation of the natural environment can impact cultural identity and damage an important source of mahinga kai

Figure 4.1: Summary of consequences from climate impacts to freshwater ecosystems and species

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 4.2 identifies potential next steps for relevant stakeholders.

Table 4.2: Potential next steps for freshwater ecosystems and species

Element at risk	Next steps	Interested / responsible parties
Waterway health	Climate impacts on waterway health and freshwater ecosystems could be evaluated at a catchment / habitat scale. This could inform strategies to improve catchment and riparian health, potentially extending current programs run by BOPRC such as the catchment environmental plans[1] that are underway to reduce land run-off and protect local rivers and streams with emphasis on 12 focus catchments.	BOPRC, Ministry for the Environment, local iwi & hapū. and landowners
Invasive species and biosecurity	Controls and community education programs relating to the ownership of exotic pest species may reduce the uncontrolled spread of ornamental pond plants and animals.	BOPRC, Ministry for Primary Industries

[1] Focus catchments (boprc.govt.nz)

5 Water availability and water quality

Healthy and abundant water is a fundamental aspect of regional wellbeing. The region's iwi/Māori, natural environment, communities, primary industries and other economic activities require clean water to sustain them.

"Te Mana o te Wai is a concept that refers to the fundamental importance of water and recognises that protecting the health of freshwater protects the health and well-being of the wider environment." NPSFM – 2020

The region's fresh water sources are characterised by volcanic lakes, major rivers, and groundwater aquifers, some of which are already fully allocated (Figure 5.1).

The highest rated risks to water *availability* relate to dryness, drought and increasing temperature. The highest rated risks to water *quality* relate to salinity stress, extreme rainfall, increased temperature, and increasing wind and storms. Table 5.1 shows risk ratings at a regional scale.

Water availability

Water availability is an important component of ensuring security of water supply for household drinking water, commercial and industrial uses, electricity generation, horticulture, and agriculture, while maintaining the ecological health of waterways. Toi Moana manages resource consents that allow for groundwater or surface water to be allocated amongst different users. A map of water availability within the groundwater allocation management zones is shown in Figure 5.1[2]. This map indicates that there are a number of groundwater catchments that are fully allocated or over allocated, meaning that the consented allowance is greater than current conservative default limits.

Table 5.1: Climate risk ratings for water availability and water quality

Risks to water availability and water quality						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Risks to water availability						
Drought, dryness & temp		🟡	🟠	🟠	🟠	🔴
Risks to water quality						
Salinity stress		🟡	🟠	🟠	🟠	🔴
Wind & storms		🟢	🟡	🟡	🟡	🟠
Temperature		🟡	🟡	🟡	🟠	🟠
Fire weather		🟢	🟢	🟢	🟢	🟢
Extreme rainfall	Streams & rivers	🟠	🟠	🟠	🟠	🔴
	Lakes	🟡	🟡	🟡	🟡	🟠
	Groundwater	*not assessed due to insufficient data*				

Drought, dryness and temperature

The region is currently experiencing drought at levels that impact water availability, the frequency of this is projected to increase with climate change. Water availability is highly sensitive to drought. High temperatures during times of drought tend to cause greater evapotranspiration and increase soil moisture deficits, driving higher irrigation demand. Warmer temperatures also tend to increase municipal

[2] This is a high-level conservative map due to be revised in 2023 Water allocation (boprc.govt.nz)

demand, which places particularly increased pressure on available water sources in coupled irrigation / municipal supply catchments (e.g. Kaituna, Tauranga City, Western Bay of Plenty). Further stress is likely to be placed on water availability in municipal catchments due to population growth. Droughts can also cause very low flows, which can result in restrictions on the taking of water and can trigger chemical contamination issues through the presence of cyanobacteria mats, causing further supply issues.

Water suppliers may need to consider how to improve the resilience of their supply by actions such as constructing bores, water storage or other sources. However many municipal water supplies are currently underutilized. If necessary, water shortage notices and municipal district restrictions can be introduced to manage water availability in response to drought. There are high costs and other environmental considerations associated with new reservoirs that may be a barrier to implementation.

Water quality

The following hazards create risks to water quality in the region. Notably, these risks may also impact water availability, which may compromise the supply of water for municipal and non-municipal uses.

Dryness, drought and increasing temperature

Stream and river temperatures are expected to increase over time as atmospheric temperatures warm. Increased temperature can act as a contaminant to aquatic life and trigger algal blooms, particularly if compounded with dryness and drought. There are few options to adapt, however riparian planting can reduce the degree of heating in waterways.

Groundwater rise

Exposure to salinity is restricted to coastal fringes. Groundwater salinity may shift inland which is likely to be accompanied by a salinity gradient change. Saltwater intrusion into groundwater aquifers is likely to be compounded through increased demand for irrigation from bores elsewhere within the aquifer due to increasing pressure gradients a freshwater is removed from the aquifer. Monitoring is ongoing however this is a complex phenomenon to monitor conclusively.

Irrigation using saline water can impact soil health (in addition to issues stemming from geothermal influence) and potentially increasing the extent of saline contamination. This can occur when excess irrigation water infiltrates through the soil into an unconfined aquifer below that may not have had that issue otherwise.

Fire weather

Warmer temperatures, lower rainfall and increased drought may exacerbate fire risk across the region, particularly in vegetated areas that may dry out and fuel fires.

Lakes and reservoirs are sensitive to contamination from ash and increased nutrient laden run-off from barren earth. This can cause contamination of water supply catchments. Groundwater and river sources have lower sensitivity to damage from fire, so are less likely to be damaged by fire. Main water sources that may be at risk from wildfire are Whakatāne, small communities within Western Bay of Plenty, and isolated communities. There are very few options to adapt.

Wind and storms

Higher wind speeds may increase mixing in lakes, stirring sediment and contributing to worsening water quality. Sensitivity to winds is highest in shallower lakes, and not considered an issue for the deeper lakes or rivers.

Extreme rainfall and flooding

Increased extreme rainfall and flooding may increase run off, taking contaminants into receiving environments (Figure 5.1). Water quality in many of the region's rivers and lakes is highly sensitive to increased runoff and sediment. This is due to high baseline suspended fine sediment (water clarity) that is below allowable thresholds set within the National Policy Statement for Freshwater Management (NPSFM). Sediment laden runoff is exaggerated during severe weather with ongoing issues relating to bank collapse, particularly in catchments with softer sediments. Land-use mitigation strategies can be adopted to reduce erosion of catchments.

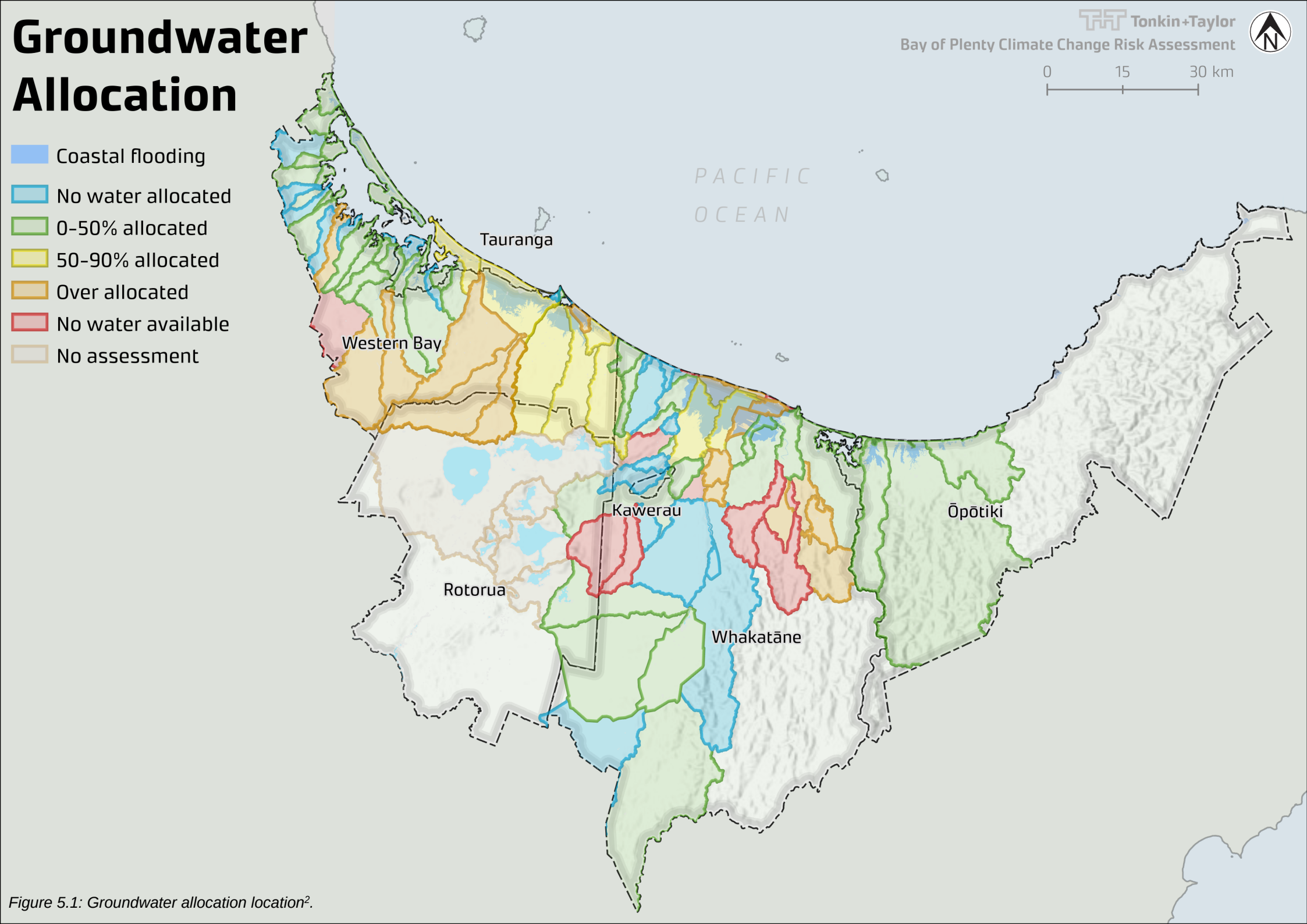


Figure 5.1: Groundwater allocation location[2].

Consequences

Consequences of risks to water availability and quality are broad and far-reaching, as summarised in Figure 5.2.

Social	Environmental	Economic	Cultural
• Lack of water can affect human health, habitation and general sanitation and hygiene. • Water scarcity can increase water pricing, further exacerbating existing inequalities. • Reduced natural amenity	• Degraded health of waterways and reduced water availability, resulting in a wider loss of biodiversity.	• Increased costs to treat and source water resulting in social impacts and impacts on the wider economy. • Loss of productivity in primary industries, causing economic losses. • Water quality impacting the amenity of the region, with impacts on tourism.	• Reduced water availability and quality will compromise food sources / kaimoana and has wider impacts on cultural identity.

Figure 5.2: Summary of consequences from climate impacts to water availability and quality

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 5.2 identifies potential next steps for relevant stakeholders.

Table 5.2: Potential next steps for water availability and quality

Element at risk	Next steps	Interested / responsible parties
Water supply	Impacts of climate change on the water supply capacity of communities may be investigated on a case by case basis to identify risks that are specific to each source.	District councils, BOPRC
Water quality	Catchment specific assessments may be necessary to inform adaptation approaches such as catchment management strategies.	BOPRC, Department of Conservation

6 Three waters infrastructure

Three waters infrastructure includes stormwater, wastewater and water supply. Together, these services manage rainfall runoff (stormwater) in urban areas, manage and treat wastewater, and provide reticulated access to potable water. Risks relating to water availability are discussed in Section 5.

The region's three waters infrastructure is located primarily within urban areas, with locations of key stormwater, wastewater and water supply infrastructure shown on Figure 6.1. The highest rated risks to three waters infrastructure relate to wind and storms, sea level rise and coastal flooding, groundwater rise, rainfall related flooding, and landslides. Table 6.1 shows risk ratings at a district / regional scale.

Sea level rise and coastal flooding risk to three waters

Parts of the three waters network that are located near the coastal edge may be exposed to coastal inundation (Figure 6.1). Lengths of exposed pipes by late century are 531 km in Tauranga City Council (TCC), 220 km in Western Bay of Plenty (WBOP), 138 km in Ōpōtiki District Council (ODC) and 490 km in Whakatāne District Council (WDC) (see Figure 6.2 and Figure 6.3), which equates to approximately 14% of the region's 9,791 km of pipes. Wastewater ponds and treatment plants are highly sensitive to inundation, the wider network may also experience damage due to salinity corrosion or reduced level of service due to increased inflow and infiltration.

Adaptation to river, surface and coastal flooding, coastal erosion, and sea level rise, groundwater rise and salinity stress

Where a location is at risk from flooding and/or coastal hazards, adaptation options for three waters infrastructure may need to be considered as part of wider place based adaptation considerations. This would factor the adaptation needs for the local community and related services and infrastructure that are at risk from these hazards.

Table 6.1: Climate risk ratings for three waters infrastructure

Risks to three waters: wastewater (WW), stormwater (SW) or water supply (WS)						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Three waters: Coastal erosion	TCC					
	WBOP					
	WDC					
	ŌDC					
WW: SLR and coastal flooding	TCC					
	WBOP					
	WDC					
	ŌDC					
WW: Groundwater rise and salinity stress	TCC					
	WBOP					
	WDC					
	RLC					
	KDC					
	ŌDC					

Coastal erosion risk to three waters

Parts of the three waters network within Tauranga City Council, Western Bay of Plenty, Ōpōtiki District Council and Whakatāne District Council are located near the coastal edge and may be at risk from coastal erosion (Figure 6.1). Lengths of exposed pipes by late century are 469 km in

Tauranga City Council, 254 km in Western Bay of Plenty, 17 km in Ōpōtiki District Council and 121 km in Whakatāne District Council (see Figure 6.2 and Figure 6.3), though exposure is relatively low relative to the overall network (approximately 9% of the region's 9791 km of pipes). Exposed parts of the network are highly sensitive to erosion damage.

Adaptation options for three waters infrastructure to coastal erosion may consist of protecting or reinforcing networks (e.g. re-lining to reduce infiltration).

Groundwater rise and salinity stress risk to three waters

Low lying, coastal areas (particularly Ōpōtiki District, and Whakatāne District) are highly exposed to high groundwater levels at present. Wastewater networks can be sensitive to infiltration when exposed to high groundwater as this can reduce levels of service, increase pumping demands, and increase the potential for overflows of wastewater. Newer networks are less prone, and systems can be adapted by the lining of pipes.

Infiltration by groundwater may reduce the capacity of stormwater systems, increasing flood risk further in areas that are already highly exposed to flooding. Adaptive capacity options include the potential to increase pumping, or consideration of a changed approach to flood management.

Water supply systems tend to have lower sensitivity to groundwater infiltration; however the pipe material may be sensitive to corrosion from increasing salinity, and structures and pipes may experience floatation.

Adaptation can be achieved through choice of inert materials and improved construction methods.

Table 6.2: Climate risk ratings for three waters infrastructure (cont)

Risks to three waters / wastewater (WW), stormwater (SW) or water supply (WS)						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
WW: Extreme rainfall and flooding	TCC	🟢	🟢	🟢	🟡	🟠
	WBOP	🟢	🟢	🟢	🟡	🟠
	WDC	🟡	🟡	🟡	🟠	🟠
	RLC	🟡	🟡	🟡	🟠	🔴
	KDC	🟢	🟢	🟢	🟡	🟠
	ŌDC	🟡	🟡	🟡	🟠	🔴
WS: Extreme rainfall and flooding	TCC	🟢	🟢	🟢	🟡	🟡
	WBOP	🟢	🟢	🟢	🟢	🟡
	WDC	🟡	🟡	🟡	🟠	🟠
	RLC	🟢	🟢	🟢	🟢	🟡
	KDC	🟢	🟢	🟢	🟢	🟡
	ŌDC	🟢	🟡	🟡	🟠	🟠
SW network: Extreme weather (rain, wind and storms)		🟡	🟡	🟡	🟠	🟠
SW catchpits: Wind and storms		🟡	🟠	🟠	🔴	🔴

Increased extreme rainfall and flooding risk to wastewater

Approximately 22% of the region's pipes are exposed to river and surface flooding either now or in the future. Lengths of exposed pipes are 1,530 km in Tauranga City Council, 368 km in Western Bay of Plenty, 67 km in

Ōpōtiki District Council and 274 km in Whakatāne District Council (see Figure 6.1, Figure 6.2 and Figure 6.3). Flooding and increased rainfall can cause increased inflow and infiltration to the network, causing higher flows to treatment plants and increased likelihood of overflows. This is most severe in Ōpōtiki District, Whakatāne District, and Rotorua District, but likely to increase across the region, with increased rainfall driving increased infiltration.

Wastewater networks can be upgraded to adapt, for example re-lining pipes, raising gully traps, and sealing manholes.

Increased extreme rainfall and flooding risk to water supply

Increased extreme rainfall and flooding may damage, flood or contaminate water supply infrastructure. Flooding of rivers can cause sediment in the water supply (e.g. Tauranga City), scour around river crossings or intake structures (e.g. Whakatāne), cause floodwater contamination of bores, or damage above ground network components.

Adaptation options may be available to address site specific issues, for example relocation or protection of erosion prone structures.

Extreme weather risk to stormwater

Extreme weather (including high rainfall) can cause blockages, washouts, or erosion around structures which can cause damage to stormwater networks throughout the region. Windfall can block culverts, leading to an increased potential for flooding. Increasing rainfall intensity will mean the capacity of existing networks is reached more frequently, driving increased overland flow, further increasing the potential for flooding (discussed further in Section 7). New systems can be designed to adapt to these issues through design and management of overland flow, however built-up areas tend to have limited space to provide for such measures.

High winds causing blockage of kerbside drains (catchpits)

Windfall and debris during high winds and storms cause blockages of catchpits, which can cause nuisance flooding and high maintenance demands. Technology and design may improve the adaptive capacity of catchpits.

Table 6.3: Climate risk ratings for three waters infrastructure (cont)

Risks to three waters: wastewater (WW), stormwater (SW) or water supply (WS)						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
SW: Groundwater rise and salinity stress	TCC	🟢	🟢	🟡	🟡	🟠
	WBOP	🟡	🟡	🟡	🟠	🟠
	WDC	🟠	🟠	🟠	🟠	🔴
	RLC	🟢	🟢	🟢	🟢	🟢
	KDC	🟢	🟢	🟢	🟢	🟢
	ŌDC	🟠	🟠	🟠	🟠	🔴
WS: Groundwater rise and salinity stress	TCC	🟢	🟢	🟡	🟡	🟠
	WBOP	🟢	🟢	🟢	🟢	🟢
	WDC	🟠	🟠	🟠	🟠	🟠
	RLC	🟢	🟢	🟢	🟢	🟡
	KDC	🟢	🟢	🟢	🟢	🟢
	ŌDC	🟠	🟠	🟠	🟠	🟠
WW: Drought		🟢	🟢	🟢	🟡	🟠
Landslides		🟡	🟡	🟡	🟠	🔴

Drought risk to wastewater

Increasing dryness and drought poses a risk to wastewater infrastructure throughout the region, particularly network extremities, where low flows can trigger blockages, and increase odour, septicity, and gas. This can be managed by chemical dosing; however this can be expensive and environmentally damaging at scale.

Landslide risk to three waters

Landslides can damage buried three waters networks, particularly in steep areas with older networks. Newer infrastructure tends to be designed to account for landslide risk. Slope stability measures can be implemented to mitigate landslides in high-risk locations.

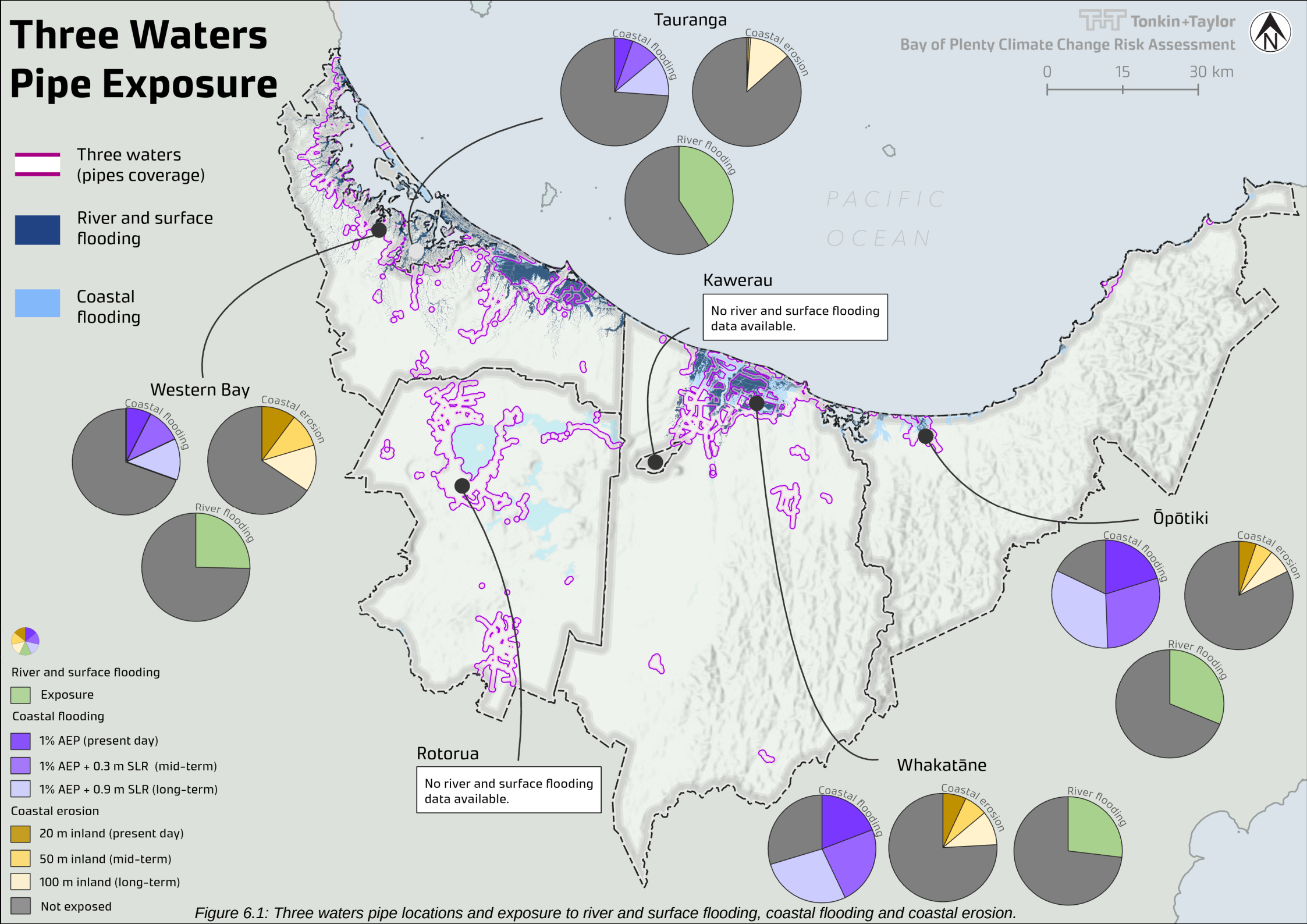


Figure 6.1: Three waters pipe locations and exposure to river and surface flooding, coastal flooding and coastal erosion.

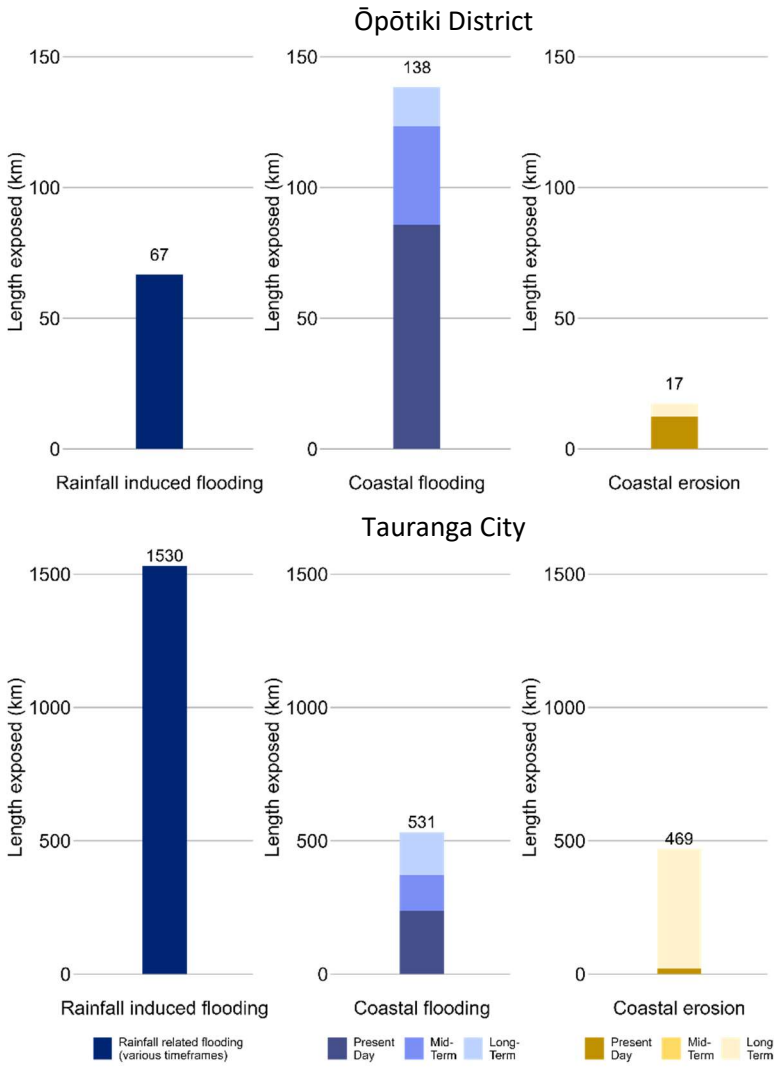


Figure 6.2: Length of exposed three waters pipes to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Ōpōtiki District (214 km total pipes)(top) and Tauranga City (3752 km total pipes) (bottom)

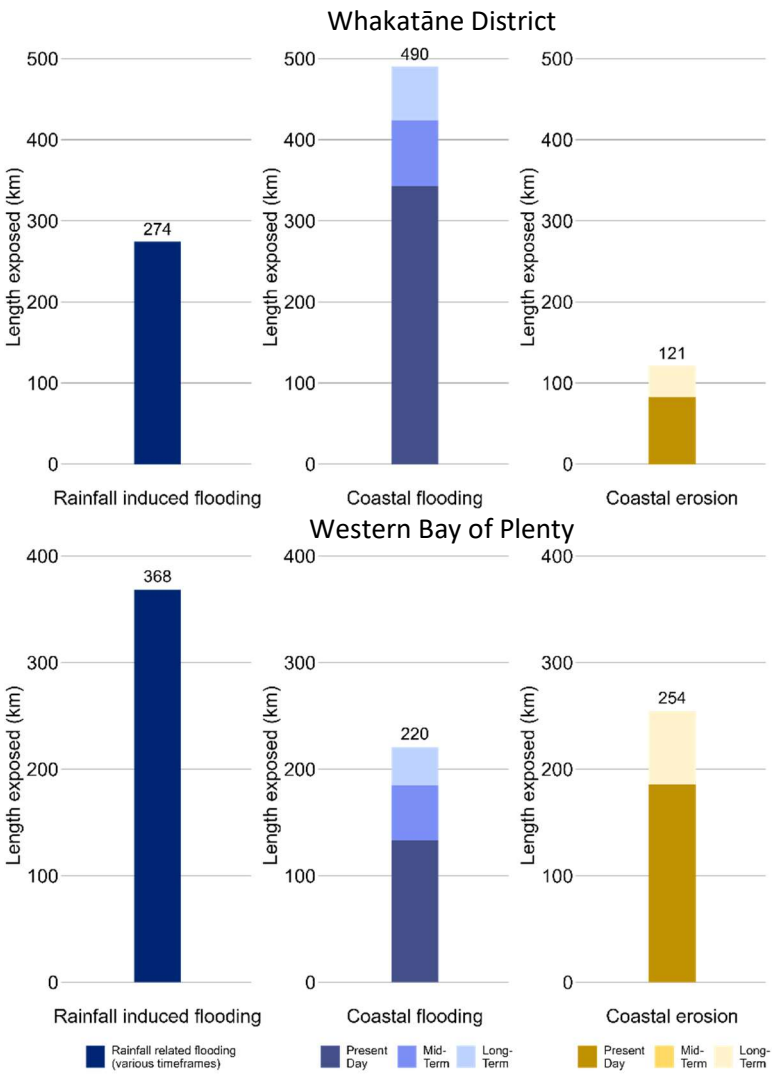


Figure 6.3: Length of exposed three waters pipes to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Whakatāne District (1020 km total pips) (top) and Western Bay of Plenty District (1451 km total pipes) (bottom)

Consequences

Consequences arising from risks to three waters infrastructure due to climate change are summarised in Figure 6.4.

Social	Environmental	Economic	Cultural
• Inundation of wastewater systems can lead to effluent discharge. This can lead to health impacts within the community. • Wastewater odour or hydrogen sulphide emissions can have impacts on community wellbeing and health. • Severe impacts on the community when homes and livelihoods are impacted by flooding.	• Wastewater can overflow into ecosystems and impact on wildlife. • Overflows can enter shallow groundwater aquifers and contaminate water quality.	• Increased costs of operation (e.g. pumping), maintenance, and capital expenditure to adapt. • Overflows can cause increasing issues relating to consents, causing increasing cost of compliance and environmental remediation. • Loss of service of wastewater or water supply can have widespread economic impacts.	• Contamination of the environment from wastewater has significant cultural impacts.

Figure 6.4: Summary of consequences from climate impacts to three waters infrastructure

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 6.4 identifies potential next steps for relevant stakeholders.

Table 6.4: Potential next steps for three waters infrastructure

Element at risk	Next steps	Interested / responsible parties
Stormwater	Co-ordination with urban planning authorities and flood managers may be required to evaluate changing flood risk to communities and ensure sufficient space is allocated to provide for increasing frequency and volume of overland flow / flooding.	District councils, BOPRC & communities
Three Waters	Site specific assessments may be undertaken to evaluate risk to specific components or sections of networks. This may feed into broader evaluation of risks to specific communities, particularly those that are highly exposed to climate hazards.	District councils

7 Flood management

Many communities within the Bay of Plenty are exposed to flooding. Coastal communities are often exposed to both river and surface flooding and coastal flooding, where settlements tend to be located at the downstream end of rivers with close connection to the coast.

Flood protection schemes

Bay of Plenty has numerous flood protection schemes that provide protection to many communities from flooding from the region's major rivers. Bay of Plenty Regional Council owns and maintains over 380 km of stopbanks, nearly 3km of concrete flood walls, 140 flood gates and 12 pump stations.

The highest rated risks to flood protection schemes relate to increased extreme rainfall, coastal erosion, and changes in seasonality and rainfall variability. Table 7.1 shows risk ratings at a district / regional scale. District summaries of risks to communities are also discussed in Volume 2.

Increased extreme rainfall and flooding

The region's flood protection schemes are inherently exposed to flooding because they are designed to convey flood flows (Figure 7.1). Stopbank integrity is sensitive to erosion from high flows, particularly when sustained over long periods of time, which may occur with increasing seasonality and variability of rainfall. The Rangitāiki flood protection scheme has a relatively high sensitivity to erosion due to its erodible construction materials. All flood protection schemes are sensitive to increasing peak flows as these reduce the scheme's protective capacity.

Multi-purpose dams are also located within the region. Dams with high potential impact (high PIC) are designed to pass extremely high inflows through appropriately designed spillways. However, two dams in the Western Bay of Plenty are known to have insufficient spillway capacity, so may be sensitive to future increased extreme rainfall and flooding.

Table 7.1: Climate risk ratings for flood protection schemes

Risks to flood protection schemes						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Extreme rainfall	Risk to stopbank integrity					
	Rangitaiki	🟠	🟠	🟠	🔴	🔴
	Others	🟠	🟠	🟠	🟠	🟠
Extreme rainfall	Risk to stopbank level of protection					
	Utuhina & Waioeka-Otara	🟡	🟡	🟡	🟠	🔴
	Whakatane & Rangitaiki	🟡	🟡	🟡	🟠	🔴
	All remaining	🟢	🟢	🟡	🟡	🟡
	Risk to non-generation dams					
	TCC	🟡	🟡	🟡	🟡	🟡
	WBOP	🟠	🟠	🟠	🔴	🔴
	WDC	🟡	🟡	🟡	🟡	🟡
	RLC	🟡	🟡	🟡	🟡	🟡
	KDC	🟡	🟡	🟡	🟡	🟡
	ODC	🟡	🟡	🟡	🟡	🟡
Rainfall variability	All stopbanks	🟠	🟠	🟠	🔴	🔴
Coastal erosion	Risk to coastal protection structures					
	Hard protection	🟡	🟡	🟡	🟡	🟠
	Dunes	🟡	🟡	🟡	🟡	🟠

Adaptation of flood protection schemes tend to result in a high cost of repair (or replacement). Bay of Plenty Regional Council is working to maintain levels of service across all schemes. Limitations on options relate to space constraints and geotechnical considerations that can limit the potential to maintain or upgrade the level of service. Some communities may need to consider relocation in future where the flood risk is too high.

Coastal erosion

Coastal protection structures will be increasingly exposed to sea level rise and increasing storm intensity (wind and storm surges) contributing to increased erosion potential (Figure 7.1). Hard protection structures are located primarily near coastal settlements including: Waihī Beach and Otūmoetai (Tauranga Harbour). The sensitivity of rock revetments (barriers) is low when events are within the design level of service. However, events that exceed the designed capacity may cause extensive damage or complete failure of the structure. Options for coastal response to climate change are complex as they are also contingent on sea level rise and evaluation of other adaptive measures.

Natural dune systems also provide protection from coastal hazards. However, erosion may cause recession of these systems. Noteworthy dune type defence systems include: Broadway (Waihī beach), Papamoa Beach (this includes settlements on dunes) and Pukehina. Planting can improve dune resilience but the potential for dunes to adapt through migration is typically limited due to development at the coastal edge.

Flood risks to communities and buildings

Many communities and buildings are exposed to flooding (Figure 7.2, Figure 7.3 and Figure 7.5). The highest rated flood risks to communities and buildings relate to increased extreme rainfall, sea level rise and coastal flooding, and groundwater rise. Table 7.2 shows risk ratings at a district / regional scale. District summaries of risks to communities are also discussed in Volume 2.

Table 7.2: Risks to communities and buildings in Bay of Plenty

Risks to communities and buildings						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
SLR and coastal flooding	TCC					
	WBOP					
	WDC					
	ŌDC					
Extreme rainfall and flooding	TCC					
	WBOP					
	WDC					
	RLC					
	KDC					
	ŌDC					
Groundwater rise and salinity stress	TCC					
	WBOP					
	WDC					
	RLC					
	ŌDC					
	TCC					

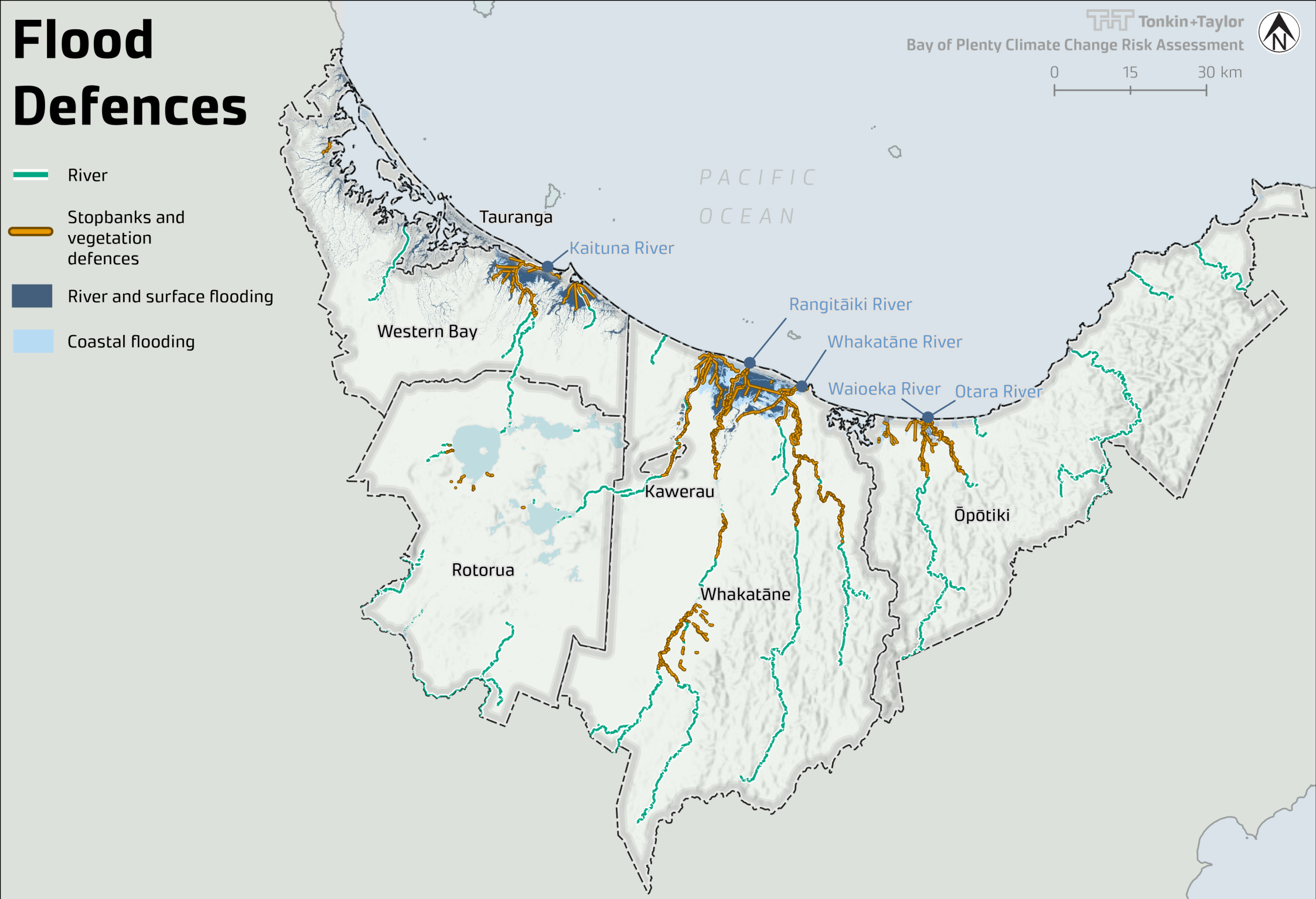


Figure 7.1: Location of floodplains, rivers and flood protection schemes.

Increased extreme rainfall

Settlements, communities, commercial centres and residential areas are at risk of damage from increasing flooding, particularly in low lying areas, downstream of lakes and adjacent to rivers (Figure 7.2, Figure 7.3 and Figure 7.5). This may be as a result of failure of flood management schemes or under capacity/failure of stormwater systems. While Whakatāne, Edgecumbe, Ngongotahā and Ōpōtiki are protected by flood protection schemes, these areas are highly sensitive to a residual risk of flooding if the scheme were to overtop or fail, as happened in Edgecumbe in 2017.

Options to adapt include refurbishment of buildings and raising floor levels. Expansion or raising of stopbanks may be an option in some locations, but can be limited by space and cost.

Sea level rise and coastal flooding

Sea level rise will reduce the effectiveness of coastal protection structures and increase the exposure of coastal settlements to coastal inundation (Figure 7.2, Figure 7.3 and Figure 7.5). Flooding of houses often results in permanent damages, requiring replacement of fittings and surfaces. Options to adapt to sea level rise can be limited over the long term given the ongoing and increasing nature of the hazard. Increases in coastal protection may be an option in some locations, however this is often costly and may not provide a suitable long term solution.

Groundwater rise

Many low-lying areas have high exposure to groundwater, including Tauranga, Waihī, Katikati, Edgecombe, Whakatāne and Rotorua. High groundwater may cause damage to building foundations, reduce the performance of buildings, and increase dampness, causing related health impacts. Communities can adapt by increased pumping and higher floor levels, however once groundwater levels approach the ground surface there tend to be limited options to adapt, other than retreating from the area.

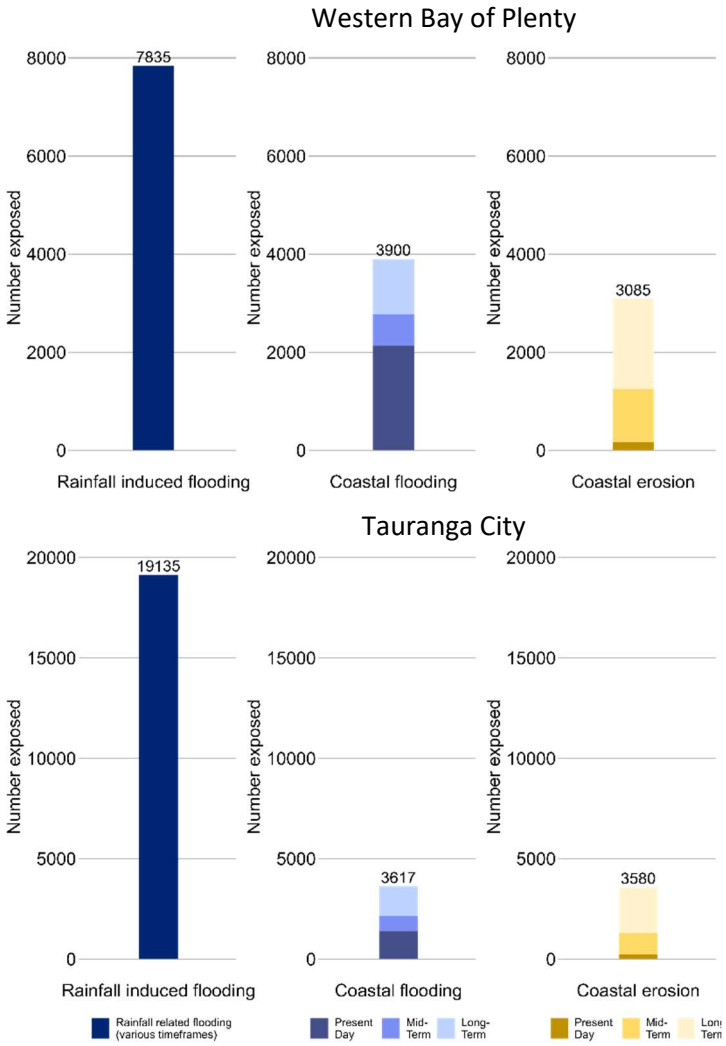


Figure 7.2: Number of exposed buildings to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Western Bay of Plenty (53,777 total buildings)(top) and Tauranga City (67,593 total buildings)(bottom)

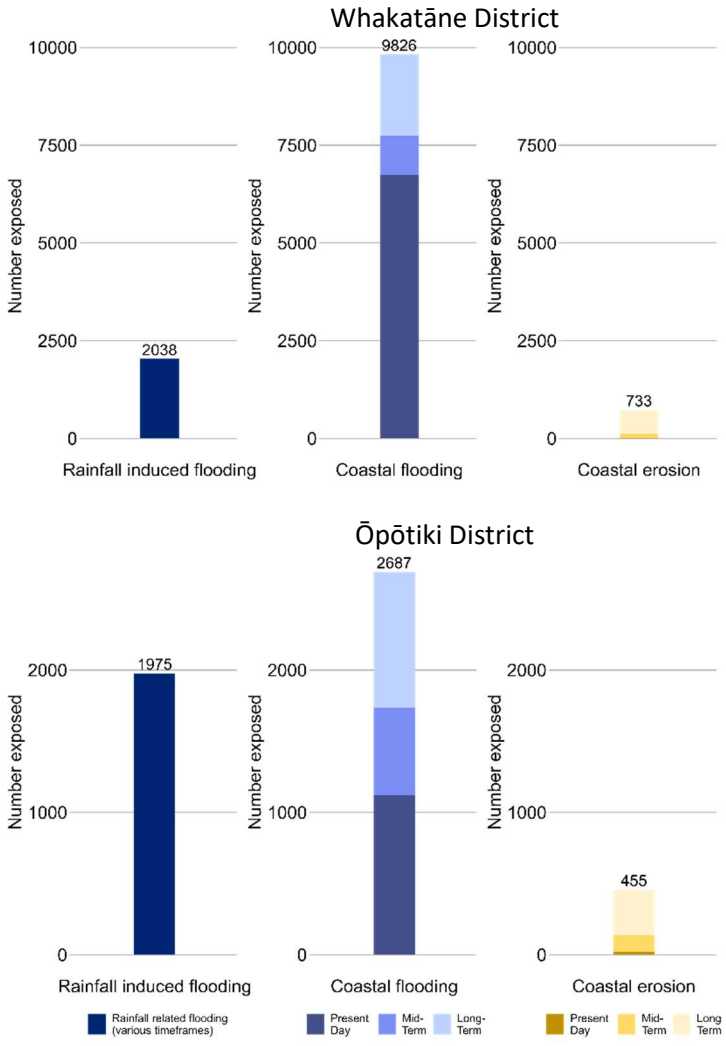


Figure 7.3: Number of exposed buildings to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Whakatāne District (34,026 total buildings)(top) and Ōpōtiki District (8,690 total buildings)(bottom)

Consequences

Consequences of risks to flood defences are summarised in Figure 7.4. Further discussion of risks to communities from flooding are discussed in Volume 2.

Social	Environmental	Economic	Cultural
• Realignment of stopbanks may impact land availability. • Flooding can cause stress and long-term impacts on mental health. Economic impacts can compound these issues.	• Flood mitigation can impact water flows into wetlands, inhibiting them to drain/function properly. • Flood damage can generate large volumes of waste by washing debris downstream and damaging or contaminating houses and infrastructure that require demolition.	• Maintaining existing service levels may require a level of investment that may become unaffordable requiring changes to land use (retreat or acceptance of higher level of risk). • Increasing damages may cause significant financial implications and can impact the ability to access insurance.	• Cultural sites are highly important to Māori. Damage or loss of these sites can be extremely traumatic for affected communities

Figure 7.4: Summary of consequences from climate impacts to flood protection schemes

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 7.3 identifies potential next steps for relevant stakeholders.

Table 7.3: Potential next steps for flood defences

Element at risk	Next steps	Interested / responsible parties
Flood protection schemes	Continue to monitor and manage flood protection schemes and coastal protection structures.	BOPRC
Exposed communities	Co-ordination with urban planning authorities and flood managers may be required to evaluate changing flood risk to communities, and ensure sufficient space is allocated to provide for increasing frequency and volume of overland flow / flooding.	BOPRC, communities, & district councils

8 Waste management

Waste management in the Bay of Plenty includes a range of services and facilities including waste collections, refuse transfer stations, active and closed landfills, composting and vermi-composting sites. Communities rely on managed collection and management of waste in parallel with waste minimisation and resource recovery practices to ensure environmental protection.

The highest rated risks to waste management operations and facilities relate to coastal erosion, extreme rainfall and flooding, groundwater, increased temperatures, and landslips as shown in Figure 8.1. and Table 8.1 shows the risk ratings at a district/regional scale.

Increased extreme rainfall and flooding

Increasing extreme rainfall and flooding may cause damage to landfills and waste management facilities (Figure 8.1). Tauranga City has 53 closed or private landfills that are potentially exposed to flooding either now or in the future, Western Bay of Plenty has six, and Whakatane has four (refer to Figure 8.2 and Figure 8.3). Inundation and erosion from flooding may affect landfill performance, potentially exposing waste and causing leachate to leak. While issues relating to flooding are uncommon at present, Tauranga, Western Bay of Plenty, Whakatāne, Rotorua and Ōpōtiki are likely to see increased exposure of some landfills to flood events over time, particularly as many of those are unlined. Adaptation options to protect or relocate landfills are expensive and can be technically difficult to implement.

Flooding of waste management facilities may cause damage to facilities or disperse waste. Ōpōtiki and Whakatāne have transfer stations that are currently susceptible to flooding. Waste transfers stations in Tauranga (Te Maunga and Maleme Street (now closed to public)) are also likely to become increasingly exposed to flooding.

Table 8.1: Climate risk ratings for waste management

Risks to waste management						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Landfills						
Extreme rainfall and flooding	TCC	🟢	🟢	🟡	🟡	🟡
	WBOP	🟢	🟢	🟡	🟡	🟠
	WDC	🟢	🟡	🟡	🟡	🟠
	RLC	🟢	🟢	🟢	🟢	🟢
	KDC	🟢	🟢	🟢	🟢	🟢
	ŌDC	🟢	🟡	🟡	🟡	🟠
Waste management facilities						
Extreme rainfall and flooding	BOPRC	🟢	🟡	🟡	🟡	🟠
	TCC	🟢	🟢	🟡	🟡	🟡
	WDC	🟡	🟡	🟡	🟠	🟠
	ŌDC	🟡	🟡	🟡	🟠	🔴
Waste operations						
Extreme weather		🟢	🟢	🟡	🟡	🟠

Additionally, high waste volumes can be generated in the community due to flood damage of property. This can place further pressure on waste management facilities (for example, as happened during the Edgecumbe floods in 2017). Regional exposure to extreme events will increase with time, as the frequency and severity of these events are projected to increase. Dealing with waste from these events is outside of normal operations, and availability of assets, contractors, trucks etc. may be a problem when responding to a large event. The capacity to adapt to

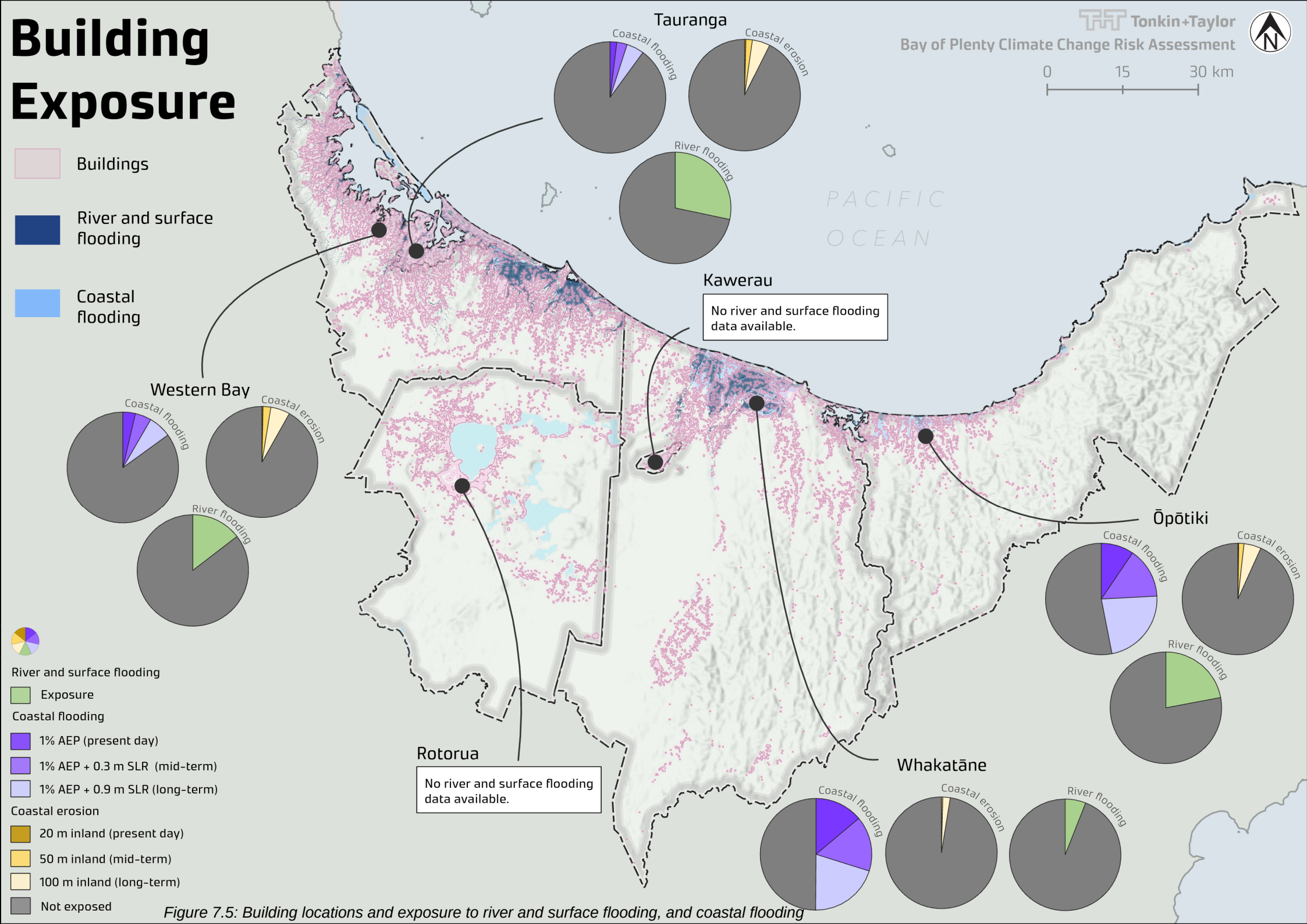


Figure 7.5: Building locations and exposure to river and surface flooding, and coastal flooding

flooding is low and may require investment in increased regional resources or support from out of the region to support flood clean-up.

Extreme weather

High winds may cause damage to structures at waste management facilities and can disrupt operations, for example, due to fallen trees blocking access to sites. Many structures will withstand high winds but some components, for example, roller doors or ad hoc structures, may be more prone to damage. The adaptive capacity of facilities is dependent on the structure, with some more easily strengthened than others.

Waste collection and processing can be impacted by strong winds causing litter to be blown around facilities, spread down the streets and across properties, and can lead to bins being knocked over, damaged and lost. As with flooding, additional waste volumes can be generated in the community due to property damage during extreme events, as occurred during Cyclone Cook in 2017. During this event waste collection services were suspended.

Adaptation measures can be implemented but tend to rely on emergency preparedness plans and strong response and recovery.

Coastal erosion

Landfills at the coastal edge may become exposed due to coastal erosion (Figure 8.1). Tauranga City has 12 landfills that are potentially exposed to coastal erosion by late century and Ōpōtiki District has two (refer to Figure 8.2 and Figure 8.3). Several districts have closed landfills that may be exposed to coastal erosion at present. Two are within Tauranga, one located within Whakatāne, and two within Ōpōtiki. Western Bay of Plenty has two coastal landfills, however the surrounding wetlands may provide protection from increasing erosion. Without protection, coastal erosion may erode exposed landfill caps and cause the release of leachate and contaminants onto beaches and the sea.

Adaptation options include the construction of coastal protection or removal of the site, both of which can be expensive.

Table 8.2: Climate risk ratings for waste management (cont.)

Risks to waste management						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Landfills						
Coastal erosion	TCC	🟢	🟡	🟡	🟠	🟠
	WBOP	🟢	🟢	🟢	🟢	🟢
	WDC	🟡	🟡	🟡	🟠	🔴
	ŌDC	🟢	🟡	🟡	🟡	🟠
Groundwater	TCC	🟢	🟢	🟢	🟡	🟠
	WBOP	🟢	🟢	🟢	🟢	🟢
	WDC	🟢	🟢	🟢	🟡	🟠
	ŌDC	🟢	🟢	🟢	🟡	🟠
Landslips	TCC	🟢	🟢	🟢	🟢	🟡
	WDC	🟢	🟢	🟡	🟡	🟠
Temp / dryness/ drought		🟢	🟢	🟢	🟡	🟡

Groundwater rise

Groundwater rise, particularly in coastal environments, can result in groundwater entering landfills and generating leachate or compromising site integrity. Exposure to increasing groundwater level is likely to increase in coastal areas as sea levels rise for sites in Tauranga City, Western Bay of Plenty, Ōpōtiki and Whakatāne. Adaptation options are costly and difficult to implement.

Landslides

Climate change can increase the frequency and severity of landslides. Landfills in most districts face low exposure to landslides, though some landfills are located near sloping ground and could be exposed to landslides as severe weather increases. In recent years landfills at Matatā, Whakatāne and Hukutaia have had issues with landslides. It is difficult and costly to carry out repairs at landfills and councils often do not have budget for such events.

Dryness, drought and increasing temperatures

High temperatures can cause cracking of closed landfill caps and can affect vegetation on the landfill cap, which can impact the cap's integrity. Landfill exposure to high temperatures is expected to increase overtime. The sensitivity of a landfill to dry-out depends on its construction and current use. Thinner caps on landfills where stock graze the cap will be more susceptible. Adaptation to high temperatures is possible, as caps are easy to repair.

Higher temperatures may increase the likelihood of odour near facilities such as vermi-composting, open landfills and refuse transfer stations. Odour problems already exist at composting and transfer stations in the Whakatāne District and are expected to be exacerbated with higher temperatures.

There are some adaptation options for odour issues, including applying different odour control solutions, investing in new technologies and improving management practices.

Waste management facilities currently manage the frequency and severity of dryness and drought within normal operating procedures. As temperatures increase this may lead to increased dust occurrence, drying of waste and increased pests. Dust is currently an issue but can be managed on site using water, though water availability may come under increasing pressure with drought. A drier environment may dry out waste causing increased wind dispersal. Increased temperatures may also lead to increased pest species, pathogens, bacteria, odour and seagull presence at waste facilities.

Increasing temperatures across the region will increase the frequency of hot days. Staff working under these conditions may experience heat stress. Changing operational hours could be used as an adaptation option to reduce staff's exposure to high temperatures.

Table 8.3: Climate risk ratings for waste management (cont.)

Risks to waste management						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Refuse transfer stations, active landfills, composting and vermi-composting sites						
Higher temperature	BOPRC	Yellow	Orange	Orange	Orange	Orange
	TCC	Yellow	Yellow	Yellow	Yellow	Yellow
	WDC	Yellow	Yellow	Yellow	Orange	Orange
Waste management facilities						
Increased fire weather		Green	Yellow	Yellow	Orange	Orange
Extreme weather		Yellow	Yellow	Yellow	Orange	Orange
Dryness/ drought		Green	Green	Yellow	Yellow	Orange
Collection staff						
Temperature/ dryness/ drought		Green	Yellow	Yellow	Orange	Red

Increased fire weather

Fire risk is already high at waste management facilities but tends to be closely managed. However, higher temperatures may increase this risk. Fires can be caused by flammable materials, for example, green waste, composting and recycling, including lithium-ion batteries, but are less likely in capped landfills.

Landfill Exposure

Landfill

River and surface flooding

Coastal flooding

Tonkin+Taylor

Bay of Plenty Climate Change Risk Assessment

0 15 30 km

PACIFIC OCEAN

Tauranga

Coastal flooding

Coastal erosion

River flooding

Kawerau

No river and surface flooding data available.

Western Bay

Coastal flooding

Coastal erosion

River flooding

Ōpōtiki

Coastal flooding

Coastal erosion

River flooding

Rotorua

No river and surface flooding data available.

Whakatāne

Coastal flooding

Coastal erosion

River flooding

River and surface flooding

Exposure

Coastal flooding

1% AEP (present day)

1% AEP + 0.3 m SLR (mid-term)

1% AEP + 0.9 m SLR (long-term)

Coastal erosion

20 m inland (present day)

50 m inland (mid-term)

100 m inland (long-term)

Not exposed

Figure 8.1: Landfill exposure to coastal flooding, coastal erosion and river flooding. Based on exposure of landfills as classified in regional hazardous site data (HAIL G3 classification).

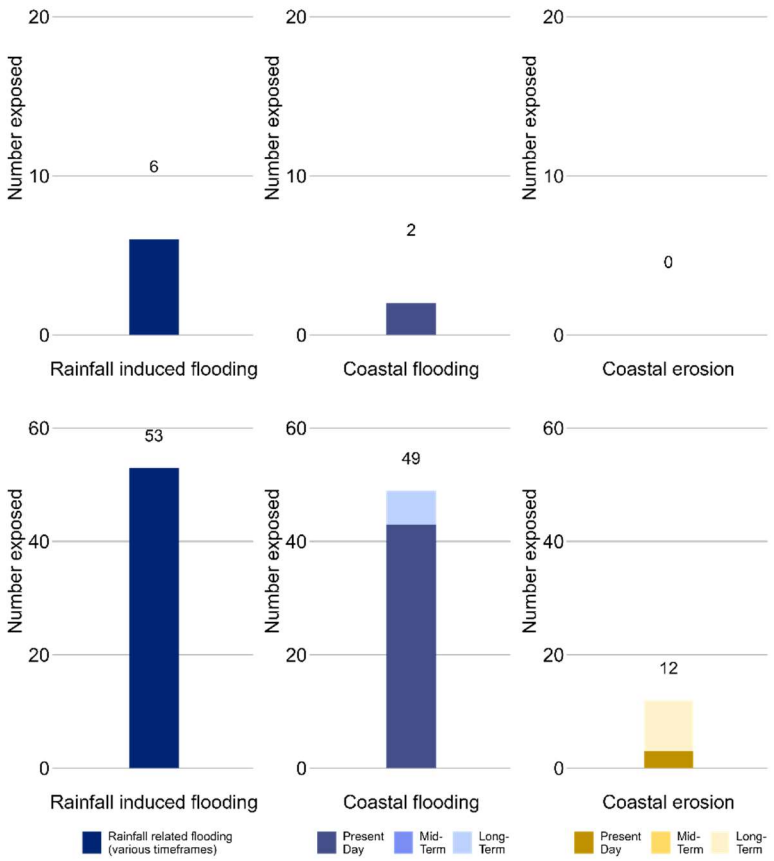


Figure 8.2: Number of exposed landfills[3] to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Western Bay of Plenty (8 total landfills) (top) and Tauranga City (53 total landfills)(bottom).

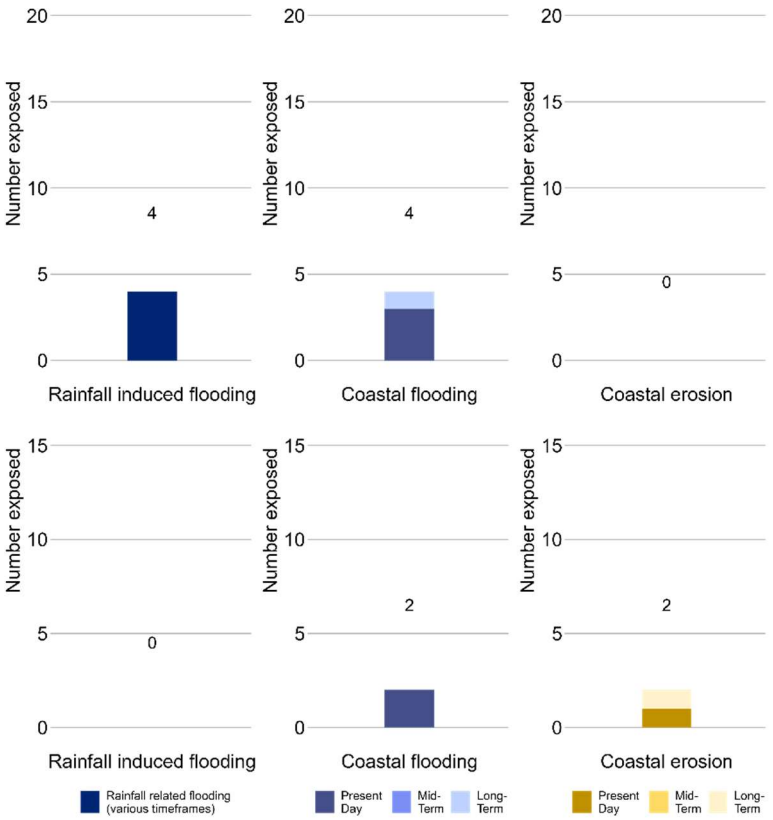


Figure 8.3: Number of exposed landfills[3] to rainfall induced flooding, sea level rise and coastal flooding, and coastal erosion Whakatāne District (16 total landfills)(top) and Ōpōtiki District (4 total landfills)(bottom)

[3] Numbers based on exposure of landfills as classified in regional hazardous site data (HAIL G3 classification)

Consequences

The consequences of climate risks to waste management are summarised in Figure 8.4.

Social	Environmental	Economic	Cultural
• Environmental contamination may impact mental health and cause a loss of amenity. • Release of toxic gases (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.	• Increased damage and disruption to waste management facilities may result in rising cost of clean-up and remediation. • Environmental contamination may result in abatement notices and fines, further increasing costs of operation. • Increasing cost of prevention of damage, and changing operational parameters e.g. composting processes and adaptation.	• Environmental contamination may impact cultural values.

Figure 8.4: Summary of consequences from climate impacts to waste management

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 8.4 identifies potential next steps for relevant stakeholders.

Table 8.4: Potential next steps for waste management

Element at risk	Next steps	Interested / responsible parties
Landfills	Site specific risk assessment and adaptation planning may be carried out to understand and prepare for climate change impacts on waste management services and operations.	District councils / facility operators
Closed landfills	Site specific risk assessment of closed landfills may be undertaken to identify those at high risk of damage and support the development of management strategies.	BOPRC, district councils

9 Transport infrastructure: roads, walkways, cycleways

Communities rely on roads, walkways, and cycleways to provide connection and access. Roads are the one of the most critical infrastructure sectors for local communities and the regional economy. They provide critical corridors for supply chains and services and allow access to many remote communities and marae within the region.

Highest rated risks to roads, walkways, cycleways relate to increasing wind and storms, increased landslides, increased extreme rainfall and flooding, and sea level rise and coastal flooding. Table 9.1 shows risk ratings at a district / regional scale.

Sea level rise and coastal flooding

Significant portions of the region's road and state highway network follow the coast and may be exposed to sea level rise and coastal flooding (refer to Figure 9.1, Figure 9.2 and Figure 9.3). Table 9.1 shows the risks to roads from coastal hazards at a regional and district level. Communities most severely exposed include Western Bay (Waihi, Pukehina, Maketu), Whakatane, Tauranga and the Ōpōtiki coastline. Sea level rise combined with severe weather and high tides may cause road closures or more permanent damage, cutting off communities.

Coastal erosion

Regionally, exposure of the road network to coastal erosion is low relative to the overall road network (refer to Figure 9.1, Figure 9.2 and Figure 9.3). Locations with highest exposure include Maungatapu Bridge area (Tauranga City), Ōhope (Whakatāne District) and sections of SH35 along the Ōpōtiki coastline. Coastal erosion may cause damage to roads, road reserves, cycleways and walkways or result in the loss of safe access to beaches.

Table 9.1: Climate risk ratings for roads, walkways, and cycleways

Risks to roads, walkways, and cycleways						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Coastal erosion	TCC					
	WBOP					
	WDC					
	RLC	*not exposed*				
	KDC	*not exposed*				
	ŌDC					
SLR and coastal flooding	TCC					
	WBOP					
	WDC					
	RLC	*not exposed*				
	KDC	*not exposed*				
	ŌDC					

Adaptation to flooding and coastal hazards

Relocation of roads away from floodplains or erosion zones is costly and can be technically challenging. Adaptation options include armouring the coast, raising, or moving the road (if there is an alternative route). These options involve high costs and disruption and must be considered as part of broader adaptation responses that consider wider community resilience.

Increased extreme rainfall and flooding

Extreme rainfall will cause increased flooding, with the highest lengths of exposed roads in Whakatāne District Council, Western Bay of Plenty, Tauranga City Council (refer to Figure 9.1, Figure 9.2 and Figure 9.3). A small amount/depth of flooding can cause disruption or outage to roads

and can interfere with walkways and cycleways. Flooding can also result in deterioration of, or damage to roads, walkways, and cycleways.

Groundwater rise

Many low-lying coastal roads may be exposed to groundwater rise. High groundwater can lead to prolonged sub-surface saturation which can lead to loss of pavement integrity and impact drainage capacities. Raising roads to adapt to rising groundwater can be complex due to overland flow management, space constraints and practicality.

Wind and storms

The region will be exposed to increasing wind and storms, which may cause road, walkway, and cycleway closures due to extreme storms and wind. Resulting windfall can obstruct traffic and block stormwater inlets, exacerbating flooding. Increased preventative maintenance of vegetation near roads can reduce impacts of windfall, however this is currently considered unfeasible at the scale required.

Landslides

The region will be exposed to increasing landslides, particularly in steep areas such as parts of Ōpōtiki, Waimana Gorge and Waiotahi Bluffs. Landslides can cause direct damage (overslips or under-slips) or outage due to overslips covering the road. Roads can be adapted by stabilisation of slopes, installation of rockslide netting and stormwater control.

Temperature

The region will be exposed to increasing temperature, which can cause reduced bitumen performance. To adapt, mixtures can be adjusted for warming temperatures or roading basecourse designed to perform under increasing temperature.

Table 9.2: Climate risk ratings for roads, walkways, and cycleways

Risks to roads, walkways, and cycleways						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Present	2050	2050	2100	2100
Groundwater rise and salinity stress	TCC					
	WBOP					
	WDC					
	RLC	*not exposed*				
	KDC	*not exposed*				
	ŌDC					
	TCC					
Extreme rainfall and flooding	TCC					
	WBOP					
	WDC					
	RLC					
	KDC					
	ŌDC					
Landslides						
Temperature						
Wind/ storm						

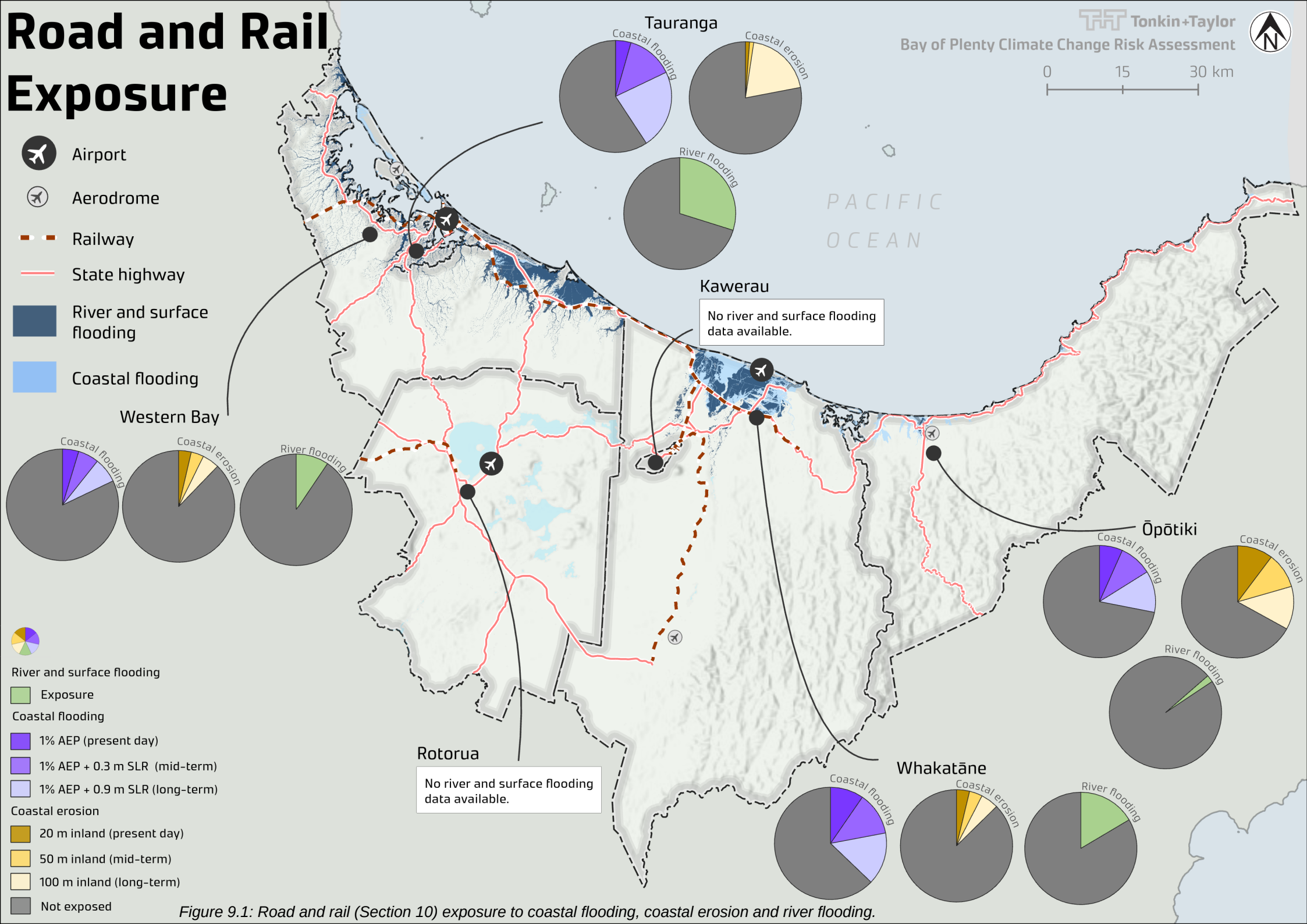


Figure 9.1: Road and rail (Section 10) exposure to coastal flooding, coastal erosion and river flooding.

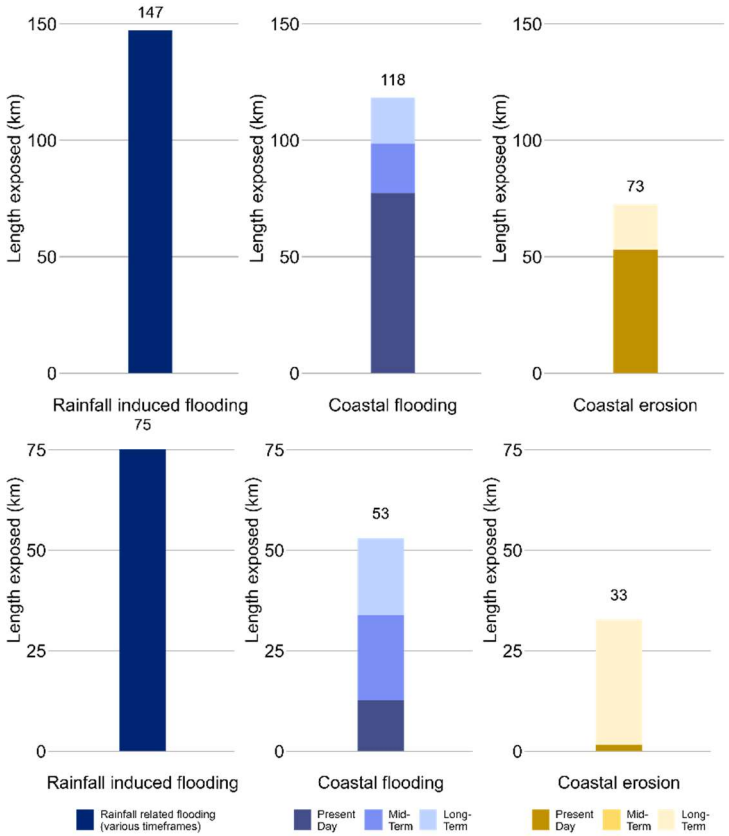


Figure 9.2: Length of roads exposed to rainfall related flooding, coastal flooding, and coastal erosion in Western Bay of Plenty (1441 km of roads)(top) and Tauranga (181 km of roads)(bottom)[4]. Note that there is no exposure data for Rotorua and Kawerau.

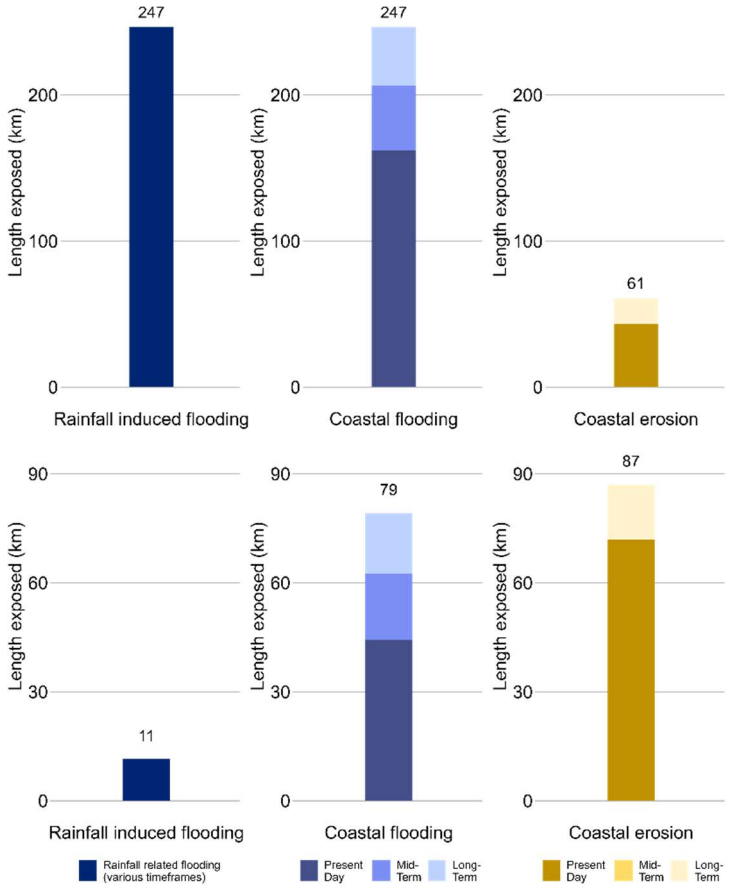


Figure 9.3: Length of roads exposed to rainfall related flooding, coastal flooding, and coastal erosion in Whakatane (1215 km of roads)(top) and Opotiki (556 km of roads)(bottom)[4]. Note that there is no exposure data for Rotorua and Kawerau.

[4] Geospatial exposure assessment of council owned transportation assets using coastal inundation and flood mapping (refer to Appendix A - Methodology for data sources)

Consequences

The consequences of damage or outage to roads, walkways and cycleways are potentially significant and are summarised in Figure 9.4.

Social	Environmental	Economic	Cultural
• Loss of access to communities • Disruption to critical routes for emergency services • Loss of access to beaches and other sites causing reduced amenity.	• Large volumes of sediment and debris that fall on road surfaces and require clean-up generate large volumes of waste.	• Increased maintenance and repair costs. • Loss of access causing impacts on the local economy.	• Loss of access to cultural sites and communities (many marae act as emergency shelters).

Figure 9.4: Summary of consequences from climate impacts to roads, walkways and cycleways

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 9.3 identifies potential next steps for relevant stakeholders.

Table 9.3: Potential next steps for roads, walkways and cycleways

Element at risk	Next steps	Interested / responsible parties
State highways	This regional assessment has identified risks to state highways, particularly due to landslides: specifically State Highway 35 from coastal erosion along the Ōpōtiki coastline, and to State Highway 2 from river and surface flooding. Waka Kotahi have identified these areas as part of previous risk assessment studies and in the process of developing adaptation strategies.	Waka Kotahi
Local roads	Risks to roads within a district could be assessed at a granular scale (using geospatial analysis) to identify risks to specific assets and vulnerable communities. This could inform asset specific adaptation and inform place based assessment of highly exposed areas.	District councils
Lifelines / Isolated communities	This assessment identified a range of hazards that may lead to increased road closures. Road closures are highly consequential to critical services and infrastructure (e.g. hospitals and emergency services), and isolated communities. Further work could build on the Bay of Plenty Lifelines Climate Change Risk Assessment to further analyse interdependencies and areas of priority, in order to develop specific adaptation strategies.	District councils, BOPRC, isolated communities

10 Transport infrastructure: Rail

Rail plays a significant freight role in the Bay of Plenty with a principal focus on the Port of Tauranga. There is approximately 320 km of rail network in the region, extending from Hamilton in the west to Taneatua and Murupara in the east. The major regional line is the East Coast Main Trunk (ECMT) which is 182 km long and runs through Hamilton and Tauranga to Kawerau. Unused portions of rail track in the region include Hawkens – Taneatua (26 km), and the Rotorua branch (48 km). There are currently no passenger rail services in the Bay of Plenty.

Highest rated risks to rail relate to rainfall related flooding, wind and storms, landslides, wildfire, sea level rise and coastal flooding and temperature. Table 10.1 shows risk ratings at a district / regional scale.

Sea level rise and coastal flooding

Rail corridors near the coastal edge may be exposed to sea level rise and flooding. This would prevent the operation of railways as closure of the tracks occurs at a flood depth of 100 mm above the top of the rail track (rail head). Flooding may compromise track stability or permanently disrupt these services.

Wind and storms

High winds can impact signalling equipment, and third-party debris can cause damage and disruptions on the network particularly tree fall (a risk in Murupara). Treefall can close the track or de-rail trains. Management of this risk tends to be reactive, however increased inspection of vegetation and maintenance programs can be implemented to minimise tree fall.

Table 10.1: Climate risk ratings for rail

Risks to rail						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
SLR and coastal flooding	Whakatāne (Matata)	🟡	🟡	🟡	🟠	🟠
	WBOP (Ōmokoroa)	🟡	🟡	🟡	🟡	🟠
	Tauranga	🟡	🟡	🟡	🟠	🔴
Extreme rainfall and flooding	Regional	🟢	🟢	🟢	🟡	🟠
	Whakatane	🟢	🟡	🟡	🟠	🔴
	Mt Maunganui yard	🟠	🟠	🟠	🔴	🔴
	Unsealed yards	🟠	🟠	🟠	🔴	🔴
Wind and storms	Regional	🟢	🟢	🟢	🟡	🟠
	Whakatāne (Murupara)	🟠	🟠	🟠	🔴	🔴
Temperature	Regional rail	🟠	🟠	🟠	🟠	🟠
	Yards	🟢	🟡	🟡	🟠	🟠
Landslides	Regional	🟢	🟢	🟢	🟡	🟠
	Whakatāne (Murupara)	🟠	🟠	🟠	🔴	🔴
Wildfire	Regional rail	🟢	🟡	🟡	🟠	🔴
	Whakatāne (Murupara)	🟢	🟡	🟡	🔴	🔴

Increased extreme rainfall and flooding

Rail corridors in low lying areas may experience increasing flooding (refer to Figure 19.1, Figure 10.1 and Figure 10.2). This can interrupt the operation of railways and cause flood damage such as erosion and ballast washouts, particularly near bridges.

Excessive stormwater at yards is an issue at present. It can cause problems relating to flooding and potential discharge of untreated runoff from unsealed yards.

Adaptation options to address flood issues at tracks and bridges may be difficult and costly. Adaptation measures to address yard related flood issues are currently being investigated and include improved stormwater systems.

Temperature

High temperatures can cause rail lines to buckle and require reduced operational speeds. Existing mitigation measures may need to be increased. These include sensors on tracks to detect when temperatures reach levels that require train speeds to reduce and de-stressing tracks.

Train operations, particularly in the yard, can cause high levels of dust This can cause health, safety and wellbeing issues for staff and the community, particularly near the Mount Maunganui yard due to the surrounding population density and polluted airshed.

Landslides

At a regional level, there are small portions of track in areas prone to landslides. Certain areas are highly exposed, particularly along the Murupara line due to the underlying geology. Tracks can be destroyed or damaged by landslides causing disruptions. Adaptation is currently mainly reactive, involving clean-up, reactive stabilisation works and reduced speeds.

Wildfire

Regionally, there is increasing exposure to fire as dry days and drought conditions increase. Vegetation is present along most parts of the network, however Murupara is most highly exposed due to the dense vegetation (related to forestry) in the area. Fires cause safety risks and can shut down rail lines. There is a limited capacity to adapt, however mitigations are currently in place along the Murupara line to detect and douse sparks, with welding activities avoided during high temperatures. Vegetation can be cleared and managed to reduce the risk; however this may be challenging to achieve at the scale required in a future, drier climate.

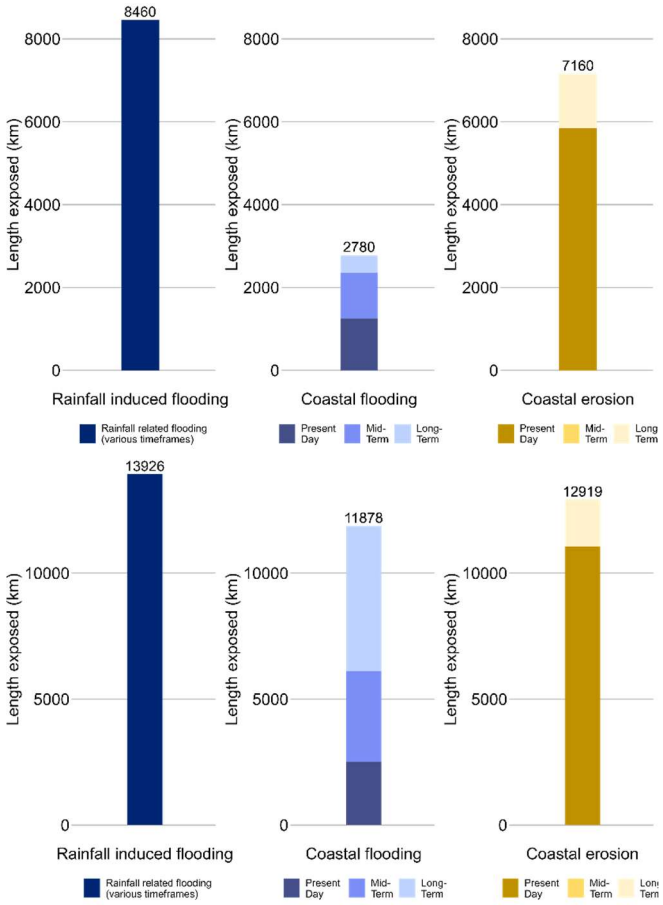


Figure 10.1: Length of rail exposed to rainfall related flooding, coastal flooding, and coastal erosion in Western Bay of Plenty (60 km of rail)(top) and Tauranga (70 km of rail)(bottom)[5]. Note that there is no exposure data for Rotorua and Kawerau.

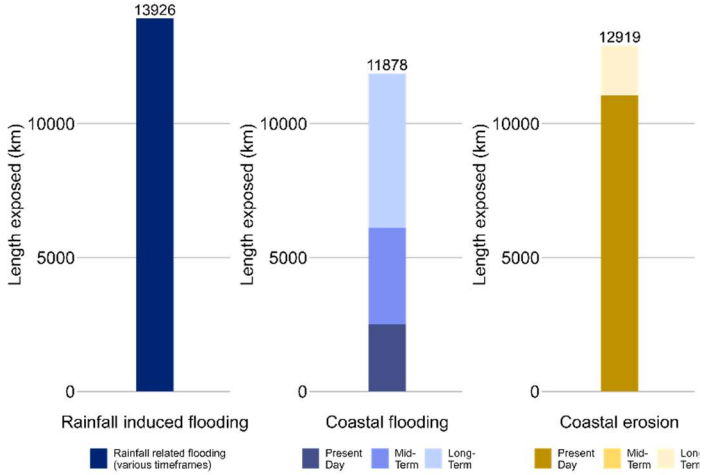


Figure 10.2: Length of rail exposed to rainfall related flooding, coastal flooding, and coastal erosion in Whakatāne (119 km of rail)(bottom)[5]. Note that there is no exposure data for Rotorua and Kawerau and Opotiki District does not have rail infrastructure.

[5] Geospatial exposure assessment of council owned transportation assets using coastal inundation and flood mapping (refer to Appendix A - Methodology for data sources)

Consequences

Consequences of climate risks to rail are summarised in Figure 10.3.

Social	Environmental	Economic	Cultural
• Contaminated runoff from rail yards may result in social impacts on local community.	• Sediment and contaminants in runoff from yards can cause environmental damage	• High cost of increasing maintenance, remediation and adaptation of rail and yards • Closure of rail lines can disrupt regional activity, notably Tauranga plays a critical connection for logging of Kinleith (Tokoraoa) and the Port of Tauranga. • Closure of Western Bay of Plenty line has impacts on regional freight and closure of the Whakatāne line impacts logging.	• Contaminated runoff from rail yards may pose a risk to cultural sites or taonga.

Figure 10.3: Summary of consequences from climate impacts to rail

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 10.2 identifies potential next steps for relevant stakeholders.

Table 10.2: Potential next steps for rail

Element at risk	Next steps	Interested / responsible parties
Rail	This regional assessment has identified risks to rail, particularly due to landslides (Murupara Line), the East Coast Main Trunk Line from coastal erosion and flooding around Tauranga, and to the Tauranga yard from river and surface flooding and stormwater issues. A detailed risk assessment of the rail line within the region is recommended, which could be included as an action in the KiwiRail Resilience Programme Business Case (RNIP 2.0). Additionally, an adaptation plan/strategy will be needed once the risk assessment has been completed.	KiwiRail

11 Transport Infrastructure: Airports & ports

Communities rely on airports and ports to provide connection, access, and freight routes. Regional flight connections are provided by Tauranga Airport, Rotorua Airport and Whakatāne Airport, all of which are owned by the local district councils. These airports provide an important connection for regional and district travel for thousands of travellers each year as summarised in Table 11.1.

Table 11.1: Summary of regional airport activity[6,7,8]

	Passengers per year (2017/18)*	Destinations	Runways
Tauranga Airport	430,000	Auckland, Wellington, Christchurch	Three grass and one sealed
Rotorua Airport	265,000	Auckland, Wellington, Christchurch	One sealed and one grass
Whakatāne Airport	25,476	Auckland	One sealed and one grass

Note: Passenger travel statistics are reported for 2017/18 due to the effects of Covid on air travel.

As New Zealand's largest port, the Port of Tauranga is an international hub port for the country. The Port's presence attracts jobs, wealth and business opportunities for the Tauranga community, the broader region and beyond. Trade at the port is dominated by exports, as summarised in Table 11.2.

Table 11.2: Port of Tauranga commercial activity summary[9]

Revenue	Imports	Exports	Ship Visits
$375.3 million	9.7 million tonnes	15.9 million tonnes	1,369

The highest rated risks to airports relate to extreme rainfall and flooding, extreme weather, sea level rise and groundwater rise. The highest rated risks to the Port of Tauranga relate to sea level rise, extreme rainfall and flooding, extreme weather, and changes in rainfall variability. Table 11.3 shows risk ratings at a district / regional scale.

Airports

Increased extreme rainfall and flooding, and coastal inundation

Tauranga Airport and Whakatāne Airport are not currently exposed to river and surface flooding in a way that impacts their operations, however increasing flooding of surrounding roads may threaten access to these airports. Rotorua has ongoing issues with river and surface flooding at present as its proximity to the lake limits drainage of the flat, low-lying airfield. During periods of intense rainfall, sealed runways must close if flooding is greater than 3 mm. These tend to open fairly quickly once rainfall stops, therefore currently cause minimal disruption to commercial/regional and emergency service flights which use the sealed runways.

[6] Whakatāne Airport Annual Report Rīpoata - ā - Tau For the Period 1 July 2017 to 30 June 2018
[7] Our History | Rotorua Airport (rotorua-airport.co.nz)
[8] About us - Tauranga Airport
[9] Port of Tauranga Limited – Integrated Annual Report 2022

Airfields may adapt to surface flooding by improving drainage, however adaptation to wider flooding issues may be technically challenging and require co-ordination across the region.

Extreme weather (wind and storms)

Severe weather causes disruption to flights, as airlines frequently do not fly due to wind or poor visibility or must divert to alternative airports. Closures may occur more frequently for inland areas (i.e. Rotorua) as the coastal weather tends to clear more quickly. The relatively low exposure of Tauranga means that it tends to receive flights from the other regional airports when they must close.

Few adaptation options are available however improvement in navigation instrument procedures may mean that the decision on whether an aircraft can land safely can be made at reduced altitudes, enabling aircraft to be less conservative with their decision making.

Temperature and relative humidity

Disruption to flights due to high temperatures are rare at present. Increased temperatures may cause tarmac to melt, which is a potential issue primarily for Whakatāne due to the current seal mix. Heat haze off tarmac surfaces may affect visibility and increasing temperature may require increased cooling at terminals (increasing costs of operation) or pose a health and safety risk to staff working outdoors. The changing relative humidity can impact the take-off length of aircraft, with variable effects depending on the specific aircraft (primarily impacting jets). Tauranga and Whakatāne are unlikely to accommodate jets in the future, however Rotorua may do so by end of century, therefore any increase in relative humidity may be an issue.

Table 11.3: Climate risk ratings for airports

Risks to airports[10]						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Extreme rainfall and flooding	TRG	🟢	🟡	🟡	🟠	🔴
	WHK	🟢	🟢	🟢	🟢	🟢
	ROT	🟡	🟠	🟠	🔴	🔴
Extreme weather	TRG	🟢	🟡	🟡	🟠	🔴
	WHK	🟢	🟡	🟡	🟠	🔴
	ROT	🟡	🟠	🟠	🔴	🔴
Higher temperatures	TRG	🟢	🟢	🟢	🟢	🟡
	WHK	🟢	🟢	🟢	🟢	🟡
	ROT	🟢	🟢	🟢	🟡	🟠
Increased relative humidity	TRG	🟢	🟢	🟢	🟢	🟢
	WHK	🟢	🟢	🟢	🟢	🟢
	ROT	🟢	🟢	🟢	🟢	🟡
SLR and coastal flooding	TRG	🟢	🟢	🟡	🟡	🟠
	WHK	🟢	🟢	🟡	🟡	🟠
Groundwater rise and salinity stress	TRG	🟢	🟡	🟡	🟠	🟠
	WHK	🟢	🟢	🟢	🟢	🟢
	ROT	🟡	🟡	🟡	🟠	🟠

[10] TRG – Tauranga Airport, WHK – Whakatane Airport, ROT – Rotorua Regional Airport

To adapt, airports can replace runway seal with an appropriate mix to be more heat resistant and increase air conditioning in terminals. Increased relative humidity requires longer runway lengths; existing runways could be expanded if space permits, however both Tauranga and Rotorua are constrained for space.

Groundwater rise and salinity stress

High groundwater degrades pavement integrity over time, reduces grass performance and contributes to increased flooding. It can lead to impacts on foundations during construction and compound operational issues such as:

- increased risks of failure in buried electrical infrastructure.
- increased wildlife that interferes with operations.

High groundwater is an issue for Rotorua at present and may be an issue for Tauranga in the future. It is not expected to be an issue for Whakatāne due to its relatively high elevation and free draining soils.

Options to adapt include improved drainage and flood control.

Port of Tauranga

Sea level rise and coastal flooding

The current height of wharves above the sea surface is expected to be sufficient to withstand projected sea level rise with allowance for storm surge. Ship loading and unloading is not sensitive to changing tide or sea level. Sea level rise may cause increasing disruption to port access via land as low-lying access routes servicing the port become prone to inundation. Port operations can generally cope with short term disruption to access, however longer term disruption may have a greater impact on operations.

Port access routes have a low capacity to adapt to coastal flooding, other than raising roads and railways which can be technically challenging and costly.

Table 11.4: Climate risk ratings for ports

Risks to ports					
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	Now	2050	2050	2100	2100
Port wharves and ship loading and unloading					
SLR and coastal flooding					
Port access					
Sea level rise					
Flooding					
Port land holdings					
SLR and coastal flooding					
Flooding					
Shipping access and berthing					
Increased extreme weather					
Port operations					
Increased extreme weather					
Changes in variability and seasonality of rainfall					

Increased extreme rainfall and flooding

Current levels of flooding are within manageable levels and do not interfere with port operations. The frequency and intensity of rainfall is projected to increase and result in greater depth and extent of flooding that may cause increased disruption to port access routes. Stormwater runoff from land holdings typically contains an initial peak of contaminants (typically fine particulates termed suspended sediment), however runoff is treated before discharge so environmental contamination is unlikely.

Options to adapt include further on-site stormwater improvements and raising the port access routes.

Increased extreme weather (storms and cyclones)

Extreme weather may disrupt shipping access and berthing, primarily relating to interruption of tugboat operation, for which there is limited capacity to adapt.

Extreme events (high winds, rainfall, storm surge) tend to have short term impacts on operations requiring suspension of some activities, particularly the shifting of dry goods and shutting down of cranes when wind speed limits are reached. To aid adaptation, the Port is undergoing a shift towards safer practices (involving less people on the ground through automation and improved equipment/technology), as well as reducing the number of buildings resulting in reduced number of assets exposed. Improved coastal protection may be an option to further support adaptation.

Variability ad seasonality of rainfall

Increases in winter rainfall may result in more frequent disruptions to port operations as increasing rain days may place pressure on handling of weather sensitive goods. This issue may become an area of focus to develop an engineered solution or drive a shift in storage practices toward building up storage over summer to compensate for wet winters.

Consequences

Consequences of climate risks to airports and ports are summarised in Figure 11.1.

Social	Environmental	Economic	Cultural
• Risk to the performance of airport facilities pose risks to safety. • Possible reductions in flights may interrupt supply chain, reduce accessibility of communities and result in economic impacts. • Disruption and increased costs to the port may raise the costs of living, leading to increased inequality.	• Increased stormwater run-off may cause contamination	• Supply chain disruption can cause increased costs to the port and resulting costs of goods. • Impacts on cruise ship terminal operation may result in tourism impacts	None identified

Figure 11.1: Summary of consequences from climate impacts to airports and ports

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 11.5 potential next steps for relevant stakeholders.

Table 11.5: Potential next steps for airports and ports

Element at risk	Next steps	Interested / responsible parties
Airports and ports	A site specific assessment of climate risk may support each airport and the Port to develop adaptation strategies to prepare and respond to climate change.	Tauranga Airport, Whakatāne Airport, Rotorua Airport Port of Tauranga
Port	The Port is a major exporter at present, therefore is highly sensitive to changes in regional economic activity particularly within horticulture, agriculture, forestry and fisheries. Working with these sectors may be useful to inform the Port in its future planning and climate adaptation.	Port of Tauranga

12 Energy and telecommunications

Energy and telecommunications are critical infrastructure sectors for local communities and the regional economy. The region has strong renewable electricity generation sources, predominantly from hydro and geothermal sources.

The region contains four hydroelectric power schemes (Kaimai, Matahina, Aniwhenua and Wheo/Flaxy) and a geothermal power plant at Kawerau. The largest of these are Matahina (80 MW) and Kawerau (107 MW). Unlike the other hydroelectric schemes, the Kaimai hydroelectric scheme does not store water but generates power through utilising the consistent inflows. The Kaimai scheme is an important source of local power generation in the Bay of Plenty.

Direct geothermal energy use is also employed in the region, which involves using geothermal heat directly, without a heat pump or power plant. Across the Taupō and Bay of Plenty geothermal area, approximately 65% of energy is used directly in industrial applications, 25% in commercial, and the remainder in residential and agricultural applications[11].

The highest rated risk to power generation relates to drought. The highest rated risks to power transmission relate to extreme weather, rainfall related flooding, temperature, landslides, and fire weather. The highest rated risks to telecommunications relate to extreme weather and fire weather. Table 12.1 shows risk ratings at a district / regional scale.

Table 12.1: Climate risk ratings for energy and telecommunications

Risks to generation & transmission, and telecommunications						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Hydro-electric/geothermal power generation						
Drought	Hydro					
	Geothermal					
Rainfall and flooding						
Transmission						
Extreme weather						
Rainfall and flooding						
SLR and coastal flooding						
Coastal erosion						
Higher temperature						
Landslides						
Increased fire weather						
Telecommunications						
Extreme weather						
Rainfall and flooding						
SLR and coastal flooding						
Increased fire weather						

[11] Geothermal energy generation | Ministry of Business, Innovation & Employment (mbie.govt.nz)

Drought

Dryness and drought may lead to reduced water availability for hydro schemes and geothermal power generation. Hydropower generation is extremely sensitive to drought as this limits the ability of the dam to store water for the purpose of generating electricity. As drought becomes more frequent, interruption to power generation may increase, placing pressure on the grid (with consequences for electricity supply and consumers).

Adaptive capacity of energy generation is low. Alternative forms of generation may be considered for the region that are not impacted by dryness or drought e.g. solar. These require significant investment.

Increased extreme rainfall and flooding

Extreme rainfall events may generate increasing flood flows to hydroelectric dams; however, these are designed to accommodate extremely large flows safely via appropriately sized spillways. Further, flood management plans are in place to enable the lowering of the dams in anticipation of large flood events.

Transmission and distribution infrastructure may be at risk from increased flooding. Assets such as poles are sensitive to waterlogged soils, which can cause failure. Electrical equipment located on the ground surface may also be damaged.

Telecommunications infrastructure can also be damaged by flooding due to water ingress or scouring of foundations.

Extreme weather

Extreme weather may result in increasing high winds during storms and rare events such as cyclones. Transmission and distribution lines are at risk due to the potential for debris causing damage to lines, wind loading and lightening. Transmission lines tend to be designed to different standards relative to distribution lines and can be less sensitive. Distribution lines have a medium adaptive capacity as these can be relocated or undergrounded (at significant cost). There will be limited adaptation options for major transmission lines and existing above ground lines which can't be put underground. Maintenance programs can limit damage from debris.

Telecommunications networks are sensitive to storms primarily due to the additional loading on the network during power outages or events when demand is high. Direct damage to telecommunications equipment during strong winds is an issue for overhead lines, however, is less of an issue for other ground based equipment.

Sea level rise, coastal flooding and coastal erosion

Increasing coastal hazards can expose distribution lines to increasing damage such as waterlogged soils causing tipping of support poles. Flooding and salinity may cause damage or corrosion of cables and electrical equipment buried or located on the ground.

Telecommunications infrastructure can also be damaged by coastal flooding due to water ingress or coastal erosion of foundations.

Adaptive capacity of transmission, distribution, and telecommunications infrastructure

Some distribution lines can be relocated or put underground to reduce exposure to hazards such as flooding, high winds, and coastal hazards, however this tends to come at significant cost. Adaptation options are limited for major transmission lines and other existing above ground lines that can't be put underground.

Telecommunications equipment often has a relatively short life span therefore, redundancies can be built into the network relatively frequently resulting in a high adaptive capacity.

Temperature

Overhead transmission and distribution cables are sensitive to higher temperatures (particularly older cables) resulting in sagging. This can increase the chance of the lines sparking a fire. Higher temperatures can also lead to inefficiencies within the network. There is potential for upgrades during maintenance cycles.

Landslides

Electricity networks are extremely sensitive to landslides which have the potential to completely destroy exposed transmission or distribution infrastructure. There is a low adaptive capacity to this, other than relocating assets.

Fire weather

Transmission and distribution infrastructure are highly sensitive to fire, particularly cables, wooden poles etc. Distribution companies are increasing monitoring for fires due to the high inherent fire risk. There are existing technologies in place to reduce fire risk (as some network components can start fires)which could be incorporated more extensively.

Telecommunications lines are highly sensitive to fire as it can destroy radio cabinets and therefore disrupt the network.

Consequences

Consequences of climate risks to energy and telecommunication infrastructure are summarised in Figure 12.1.

Social	Environmental	Economic	Cultural
• Emergency response effort may be inhibited, causing health and safety impacts, and anxiety. • Power outage may compromise food storage, communications, and healthcare.	• Drought may increase tension on the allocation and of water for competing purposes (e.g. power generation, irrigation and environmental sustainability).	• Economic loss if communication is not possible. • Loss in productivity	• Many marae act as emergency shelters and may be impacted by power and telecoms outages causing increased stress and reduced wellbeing. • Loss of energy and telecoms to isolated rural areas may impact the ability to conduct cultural practices.

Figure 12.1: Summary of consequences from climte impacts to energy and telecommunications

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 12.2 identifies potential next steps for relevant stakeholders.

Table 12.2: Potential next steps for energy and telecommunications

Element at risk	Next steps	Interested / responsible parties
Energy generation	Detailed risk assessment into energy generation schemes within the Bay of Plenty, and the development of adaptation strategies. Review potential of other forms of energy generation e.g., solar.	Pioneer Energy/ Manawa Energy/Meridian Energy
Energy transmission	Transpower are in the process of developing their risk assessment and climate adaptation strategies.	Transpower
Energy distribution	Detailed risk assessment of climate risk within the region may support distribution providers to develop adaptation strategies to prepare and respond to climate change. Providers can also draw on work completed as a part of the Bay of Plenty Lifelines Climate Change Risk Assessment (which has informed the analysis here).	Distribution providers
Tele-communications	Detailed risk assessment of climate risk within the region may support distribution providers to develop adaptation strategies to prepare and respond to climate change. Providers can also draw on work completed as a part of the Bay of Plenty Lifelines Climate Change Risk Assessment (which has informed the analysis here).	Telecommunication providers

13 Economic industries: Tourism

Tourism in the Bay of Plenty supports the regional economy, it contributed 3.8% ($664m) of the regional GDP in 2021[12]. Tourism related GDP dropped 36.9% between 2020/2021 due to the effects of Covid-19.

Tauranga contributes the highest proportion of regional tourism spending at 49%, followed by Rotorua (35%), with other districts contributing much less. Approximately 20% of tourism in Rotorua is forestry based.

Highest rated risks to tourism relate to increased temperatures and fire weather in Rotorua and increasing dryness and drought more generally. Table 13.1 shows risk ratings at a district / regional scale.

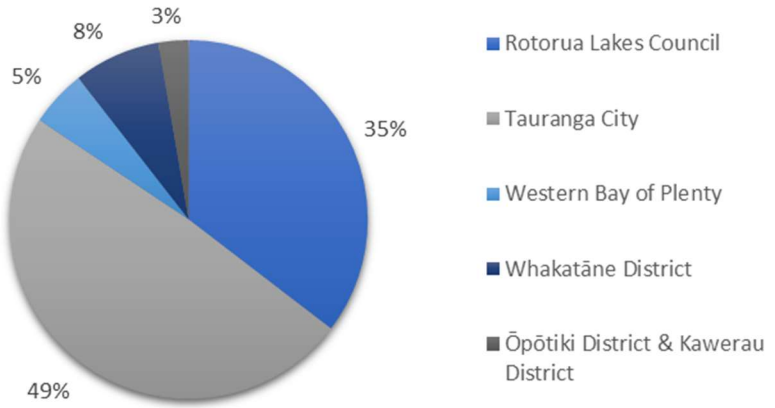


Figure 13.1: Proportion of tourism related GDP by district

Table 13.1: Climate risk ratings for tourism

Risks to tourism						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Dryness and drought	Rotorua	🟢	🟡	🟡	🟡	🟠
	Coastal BOP	🟢	🟡	🟡	🟡	🟡
	General regional tourism	🟡	🟠	🟠	🟠	🟠
Extreme rainfall and flooding	Rotorua	🟢	🟢	🟢	🟢	🟡
	General regional tourism	🟢	🟢	🟢	🟢	🟡
Higher temperatures	Rotorua	🟡	🟠	🟠	🟠	🔴
Increased fire weather	Rotorua	🟡	🟡	🟠	🟠	🔴
Groundwater rise	Rotorua	🟡	🟡	🟡	🟠	🟠
Coastal erosion		🟢	🟢	🟢	🟡	🟡
Marine heatwaves and ocean chemistry changes		🟢	🟢	🟢	🟡	🟡

Dryness and drought

Increasing drought may impact the amenity for general tourism throughout the region. Within Tauranga and other coastal settlements water availability is a primary constraint, where high numbers of summer

[12] https://ecoprofile.infometrics.co.nz/Bay of Plenty Region/Tourism/TourismGdp

tourism exacerbates the crisis. Relative to other areas of New Zealand and international destinations, the sensitivity of tourism to drought in the Bay of Plenty is low.

A large proportion of Rotorua's tourism activity is related to the surrounding forests, geothermal attractions and lakes. Forests are likely to be affected by drought which may impact their potential to host tourism activities. The sensitivity of geothermal attractions to drought is unknown, however impacts on water availability and water quality may impact water-based tourism, as well as hospitality services.

The capacity of some activities and attractions to adapt to drought is low, however the tourism industry is inherently adaptive, and it is likely that alternative attractions are developed in response to changing constraints. Some activities or locations may have a higher adaptive capacity e.g., cultural elements of tourism.

Fire

Within Rotorua, increasing fire risk may result in closure of forests during times of high temperatures and extended dry periods, with longer duration closures having the greatest impact. Closure of forests has a high impact on Rotorua tourism activities including canopy tours, zip lines, general eco-tourism, and mountain biking. Forests are a major venue for events and unscheduled or seasonal closures may impact these events with broader economic impacts.

Tourism may adapt and shift away from forest-based attractions if fire risk becomes too high. This could include a shift toward activities in native forests with a lower fire risk, requiring changes by the Department of Conservation to activities permitted in the conservation estate. Some aspects have lower adaptive capacity e.g., the Redwoods Forests are an iconic part of the Rotorua tourism sector.

Temperature

Due to the number and unique character of lakes in the area, Rotorua is highly sensitive to higher temperatures and the associated impacts on water quality such as increased algal blooms. Deteriorating water quality affects water sports, amenity and reputation which may impact the area's fishing charters and associated tourism, and its ability to host events e.g., multisports, and triathlons. The Rotorua district has a low adaptive capacity, as the 18 freshwater lakes form an integral part of Rotorua tourism and attractions, and it is very difficult to disconnect from this. An option to adapt could include investment in water parks & other artificial features.

Increased extreme rainfall and flooding

Increased extreme rainfall and flooding throughout the region can decrease the desirability of the area, due to the damage caused to the natural beauty of the region. It can also lead to reduced accessibility due to airport disruption, damaged roads, and arterial routes. Flooding may result in a reduction in visitor numbers, particularly activities reliant on being outdoors and the natural environment e.g., camping holidays (Matatā, Te Uruwera).

Groundwater rise

Within Rotorua, low groundwater levels can trigger less frequent geothermal activity which may result in closure of attractions e.g., Te Whakarewarewa. Conversely, increased geothermal activity could have a positive impact on attractions, and potentially create new ones. Increased geothermal activity may pose increased health and safety risks to the industry, however it may be possible to for tourism enterprises to mitigate these risks through management and health and safety protocols.

Coastal erosion

Many popular coastal tourism destinations will be impacted by coastal erosion. These tend to be holiday destinations, camping sites and areas of high natural amenity, such as Ōpōtiki (loss of public reserve), Ōhope Beach, Waihī Beach, Mount Maunganui Main Beach, and Pilot Bay. At a regional scale, the adaptive capacity of the tourism industry is high and is likely to adapt to this type of disruption by strengthening activities in less affected areas.

Marine heatwaves and ocean chemistry changes

Coastal tourism in the Bay of Plenty is highly connected to coastal and marine activities. Declining ecosystem health and amenity may be damaging to tourism. For example, the strong charter boat industry (Whakatāne) may be impacted if wild fisheries decline. Additionally, warmer temperatures may drive an increase in the presence of sharks which may impact beaches that are currently considered safe.

The tourism industry tends to be highly adaptive and is likely to embrace new opportunities that arise. Recreational fishing is very responsive to changing fish populations and is likely to expand into any new opportunity that arises. For example, Ōpōtiki mussel farm has had a very positive impact on tourism and growing aquaculture activities may provide increasing tourism opportunities that are less sensitive to climate change. Specific adaptation options include shark nets to ensure beach safety.

Consequences

Consequences arising from climate risks to tourism are summarised in Figure 13.2.

Social	Environmental	Economic	Cultural
• Loss of tourist activities may impact mental health and wellbeing.	• Tourism may shift to areas which are currently undeveloped e.g. native forests	• 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 across the Bay of Plenty.

Figure 13.2: Summary of consequences from climate impacts to tourism

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 13.2 identifies potential next steps for relevant stakeholders.

Table 13.2: Potential next steps for tourism

Element at risk	Next steps	Interested / responsible parties
Tourism	Although the tourism industry of the region is inherently adaptive, a focused assessment of climate risk may support the industry to adapt to any challenges and opportunities that climate change may present.	Tourism NZ, Regional Tourism Organisations.

14 Economic industries: Agriculture

Agriculture in the Bay of Plenty supports the regional economy and contributes 2.8% to the region's GDP[13]. Dairy cattle farming dominates the regional agricultural contribution at 76% ($369m), followed by sheep, beef and grain at 18% ($86.7m), and poultry, deer and other livestock contributing the remaining 6% ($31m).

The highest rated risks to agriculture relate to sea level rise and coastal erosion, flooding, landslides, erosion and soil loss, drought, increasing temperature, groundwater rise and salinity stress, and fire weather. Figure 14.3 shows the agriculture exposure to coastal flooding, coastal erosion, and river flooding. Table 14.1 shows risk ratings at a district / regional scale.

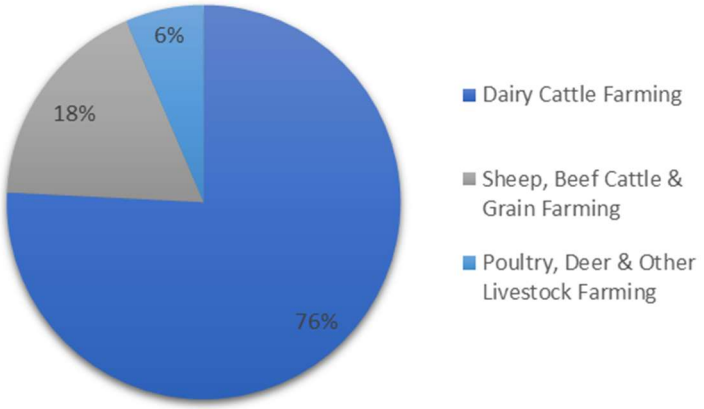


Figure 14.1: Proportion of livestock farming by type (determined by GDP)

Table 14.1: Climate risk ratings for agriculture

Risks to agriculture/ livestock					
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	Now	2050	2050	2100	2100
Extreme rainfall and flooding					
Extreme weather					
Landslides, erosion, and soil loss					
Dryness and drought					
High temperatures					
SLR and coastal erosion					
Groundwater rise & salinity stress					
Increased fire weather					

Increased extreme rainfall and flooding

Some of the region's most intensive farming is located on low-lying fertile peat soils which will be increasingly exposed to flooding, compounded by sinking which is characteristic of peat soils (Figure 14.3). Approximately 191 km^2 of land area used in livestock farming may be exposed to river and surface flooding either now or into the future (9.6% of total land

[13] https://ecoprofile.infometrics.co.nz/Bay of Plenty Region/Gdp/Structure

area) (Figure 14.2). Flooding of farms can cause extensive damage to infrastructure, livestock, pasture and feed crops, which can result in increased costs to farmers.

Adaptation measures include adoption of wet-tolerant pasture species, riparian planting and wetland conversion to attenuate flows resulting in reduced peak and reducing the extent of flooding. Infrastructure investments such as elevated platforms to hold stock (stand-off pads) increased drainage or flood protection measures may provide increased resilience to farms.

Wind and storms

Exposure to extreme events (e.g., high winds and cyclones) is currently low, but may increase over time. Extreme events may impact animal welfare, particularly if events occur during crucially important times like lambing/calving. Extreme events can also deplete feed sources, impacting livestock health and production. Farmers may adapt by planting shelterbelts (where land is available) and improved planning around where to plant/build. Improved weather forecasting improves resilience as farmers can prepare for extreme weather such as pre-emptive movement of stock (particularly during winter).

Landslides, erosion and soil loss

Soil loss as a result of heavy rainfall is a critical issue for farmers, as it can have long term impacts on the productivity of the land (Figure 14.3). Erosion and landslides can result in loss of capital due to damage to crops on hill country and can cause significant damage to tracks and areas where overland flow paths accumulate. The adaptive capacity of agriculture primarily relates to land use change on steeper slopes by conversion to regenerative planting. There are examples within the region that demonstrate the effectiveness of land management to minimise soil loss, however this takes time, planning and investment.

Dryness and drought

Drought and extended dry periods contribute to reduced availability of water, which is critical to farm productivity mainly due to a reduction in productivity of high quality grasses such as rye and clover. This impacts livestock feed affecting sheep, wool, beef, and milk production.

Farmers can shift dairy cattle to new pastures, adopt more deep rooted grass species and increase the number of ponds for water storage. Demand for large scale irrigation may increase, but this could be constrained by water availability. The changing climate may drive a southward shift in farming activity due to the improved viability of land that has previously been unsuitable for farming.

Increasing temperature

Livestock farming is sensitive to high temperatures, which can cause animal welfare issues relating to heat stress and loss of production. Livestock experience major issues at 35˚C, where production rapidly declines. Warmer temperatures and reduced frosts also increase the occurrence of parasites, tics, filaria (although cattle can build up resistance) and facial eczema. Approaches for farms to adapt include increasing shade trees and construction of animal housing with good airflow.

Coastal flooding, groundwater rise and salinity stress

Approximately 228 km^2 of land area used in livestock farming may be exposed to coastal flooding by late century (11.5% of total land area) (Figure 14.2). Coastal farms are sensitive to coastal flooding causing salinity stress which may prevent farming in these areas (Figure 14.3). Rising groundwater can cause nutrient loss (due to leaching) and impact the effluent disposal of farms.

Coastal farms have a low adaptive capacity. Protection of the land requires significant capital. Farmers may need to retire land e.g. through the establishment of coastal wetlands to improve the protection of remaining areas further inland. Adaptation takes time, planning and investment.

Fire weather

High coverage of trees around livestock farms contributes to high fire risk, which may increase as carbon farming and riparian planting increases. If fire occurs, these farms are likely to be highly exposed, particularly during very dry conditions with high winds, which can blow fire long distances. Increasing rural density (e.g. lifestyle blocks) contributes to increased fire risk as more landowners are likely to light fires (e.g. burning rubbish). Fire can be devastating if it occurs and may coincide with times of drought, where water availability to manage fires is low. The adaptive capacity of farming can be improved by fire breaks and measures to control fire usage, such as fire bans and community education.

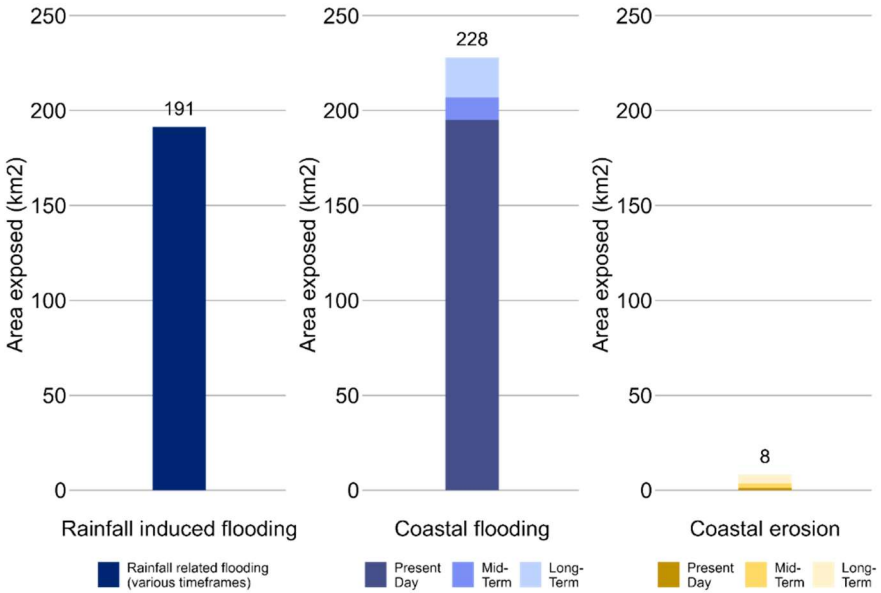


Figure 14.2: Land area of sheep, beef, deer and dairy farming exposed to river and surface flooding and coastal hazards (1991 km^2 total area)

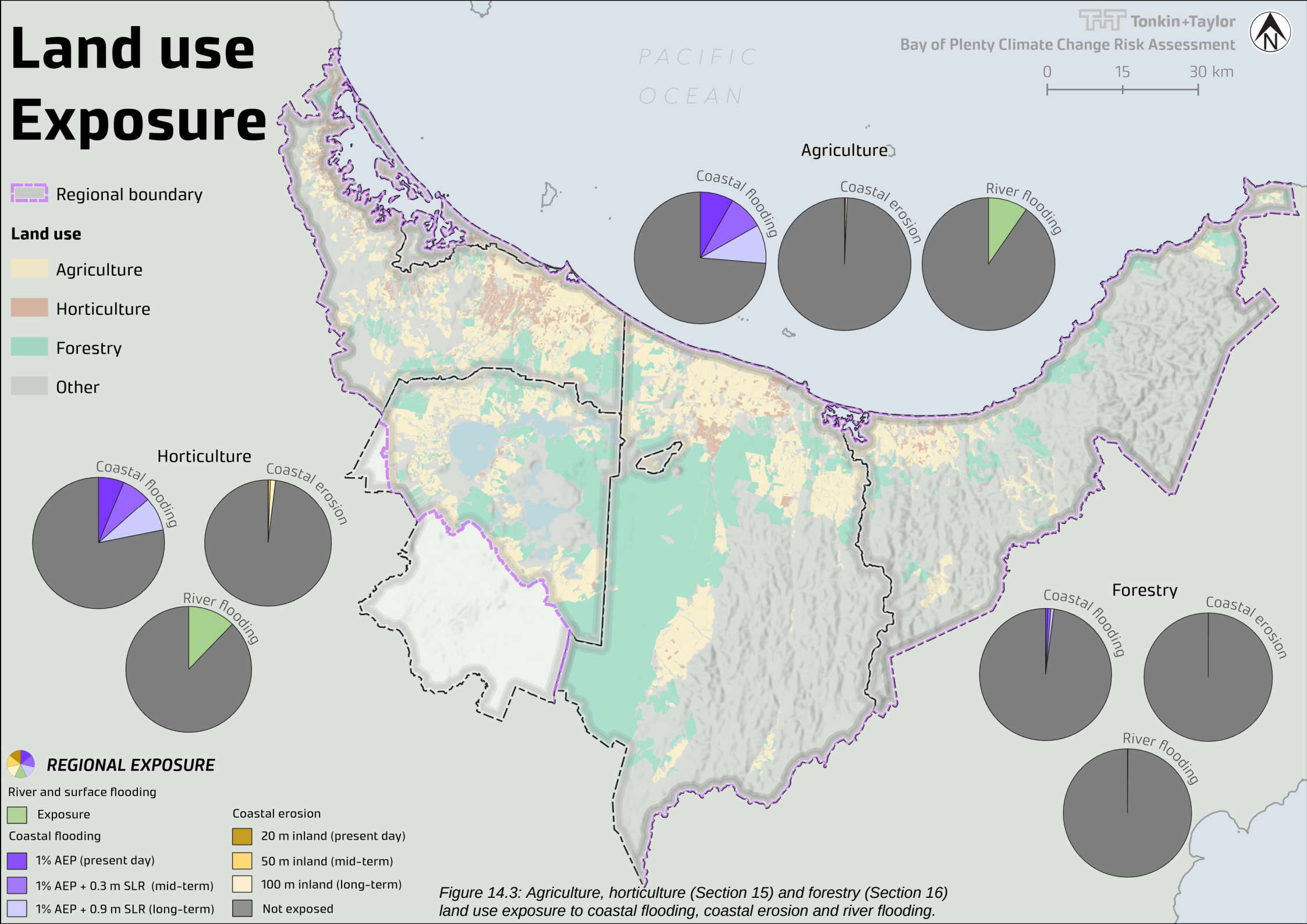


Figure 14.3: Agriculture, horticulture (Section 15) and forestry (Section 16) land use exposure to coastal flooding, coastal erosion and river flooding.

Consequences

Consequences arising from climate risks to agriculture are summarised in Figure 14.4.

Social	Environmental	Economic	Cultural
• Adjusting to change is a major undertaking for some and may lead to increased farmer stress to meet climate standards. • Reduced productivity leading to increased mental health implications, particularly in farmers.	• Increasing soil loss and erosion and associated increasing pathogens in runoff from farmland may cause damage to waterways, and harbours.	• Increasing costs for farmers (due to loss of production, and climate adaptation). • Water and feed shortages may drive farmers to destock, resulting in reduced productivity and impacts on the economy and employment. • Reduced food security and rising price of food	• High impact on Māori as there is a high proportion of Māori and strong presence in the Eastern Bay (dry stock, dairy). • Traditional food gathering may be impacted as a result of water quality issues

Figure 14.4: Summary of consequences from climate impacts to agriculture

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 14.2 identifies potential next steps for relevant stakeholders.

Table 14.2: Potential next steps for agriculture

Element at risk	Next steps	Interested / responsible parties
Waterways	Continuation and enhancement of catchment management practices to improve waterway health and reduce soil loss (e.g., BOPRC catchment environmental plans[14] that are underway to reduce land run-off and protect local rivers and streams with an emphasis on 12 focus catchments).	BOPRC and landowners
Farms	Farm scale or local area assessment of climate risk may help farmers to identify approaches to support climate adaptation. This could feed into a continuation and expansion of initiatives to improve farmer resilience through education and support (requiring resources and funding). Many of the initiatives that will support adaptation are long term and take many years to implement.	Farmers, Federated Farmers, Dairy NZ, Beef and Lamb NZ, Fonterra, Ministry for Primary Industries.

[14] Focus catchments (boprc.govt.nz)

15 Economic industries: Horticulture

Horticulture in the Bay of Plenty supports the regional economy and contributes 1.9% to the region's GDP[13]. Kiwifruit and avocado are dominant crops within the region, accounting for a total of 96% of the total planted area of crops in the region (Figure 15.1:). The kiwifruit industry is the dominant export crop of New Zealand, valued at $2,709m in 2021, 80% of which is grown in the Bay of Plenty. Though a smaller export market at $211m, the avocado market is fast growing with significant increases in recent years. 46% of New Zealand's avocado orchards by land area are located within the Bay of Plenty.

Highest rated risks to horticulture relate to coastal hazards, increasing temperature, decreasing winter chill, pests and disease, drought, extreme weather, flooding fire weather and groundwater rise and salinity stress. Figure 14.3 shows the horticulture exposure to coastal flooding, coastal erosion and river flooding. Table 15.1 shows risk ratings at a district / regional scale.

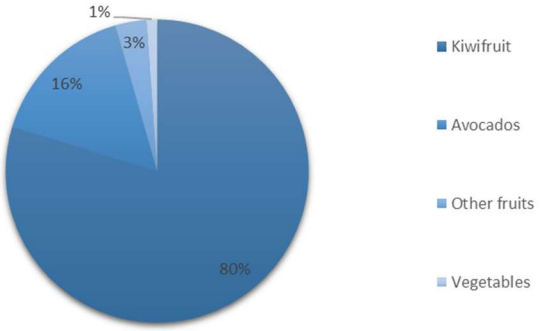


Figure 15.1: Planted land area (% ha) by horticultural activity[15]

Table 15.1: Climate risk ratings for horticulture

Risks to horticulture					
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Decreased winter chill						
Temperature						
Pests and disease						
Dryness and drought						
Fire weather						
Extreme weather						
Flooding						
Coastal hazards						
Groundwater rise and salinity stress						

Decreased winter chill

Timing of frost /chilling is critical for kiwifruit budding and fruit maturation. Low temperatures in autumn encourage fruit maturity, and temperatures between 0-7°C during winter encourage a greater budburst. Lower winter chill hours can result in variable budbreak (ripening varies across a vineyard), poorer quality kiwifruit, lower yield and delayed leaf drop after harvest, causing disruption to pruning. The sensitivity of crops may vary between varieties, with organic orchards most severely impacted. Current growing practices are not particularly adaptable, however growing techniques can be adopted to suit warmer

[15] freshfacts-2021.pdf

conditions. Vines can be treated with Hi-Cane to promote budding in warmer temperatures, although this is not used in organic farming and the ongoing use of Hi-Cane on conventional farms is currently under assessment due to health and environmental concerns.

Temperature

Increased temperatures may shift fruit crops out of their optimal temperature bands and can advance the flowering in some crops (to winter/early spring). This can leave them more vulnerable to yield loss from spring frosts . The demand for irrigation may increase with increasing temperatures, reduced summer rainfall and drought. Warmer temperatures may cause fruit to be warmer when picked which can cause spoilage or increase the demand for cooling, shift ripening and harvest time, and cause heat related stress on pickers. Adaptation measures include shifting harvest times, increased cooling in packhouses and changing working hours of pickers.

Increased temperature and reduced frost contribute to increased fungal disease (which is currently an issue affecting exports), rising phytosanitary pests e.g., scale and the introduction of new, exotic pests or diseases; for example, the Queensland fruit fly could survive New Zealand winters if the winter climate warms by 0.7 degrees. Crops are highly sensitive to pests, which have the potential to destroy an entire harvest. The introduction of an exotic disease can be devastating.

Adaptive capacity includes increased pesticide use and increased monitoring to enable early control of outbreaks. Selective breeding may be an option to develop resistance to pests and diseases.

Dryness and drought

Horticulture is highly sensitive to drought, particularly in relation to reduced water availability as increasing evapotranspiration increases the demand for irrigation. Drought stress can decrease productivity due to reduced fruit size and numbers (20-30% loss), and can lower the quality of the fruit, resulting in loss of return.

Options to adapt include establishment of growers into new parts of the region, or other regions, increased irrigation, and installation of dams to improve water availability. There is potential to develop practices to reduce water dependency through increased soil carbon content and education of farmers on the optimum amount of water needed.

Fire weather

Increasing temperature and drought may lead to increased fire weather, particularly in areas with high vegetation cover. Kiwifruit and avocado orchards are highly sensitive to fire. Exposed fruit may not be salvageable as they can experience smoke damage. Ashfall on kiwifruit is also an issue, however avocados can be washed so are less sensitive.

Extreme weather (wind, storms, frost events and changing seasonality)

Heavy rain, wind, hail and changing seasonality may cause damage to kiwifruit prior to harvest. Damaged fruit can lead to reduced yield and less productive crops. Recent examples include an extreme wind event in late 2021 where Bay of Plenty growers lost up to 10-25% of the crop, and in October 2022 where an unseasonal frost event during spring had significant impacts on early spring growth.

Changing predictability of weather can impact fruit quality and disrupt orchard operations. Wet conditions can result in a sudden change in crop size, where the fruit fills with water, changing the taste. Fruit splitting can occur if rainfall is quickly followed by sunshine at a critical stage of fruit maturity. Harvest timing is highly sensitive to weather as dampness can lead to storage and fungal problems.

Options to adapt include the use of artificial cover nets or shelter belts. Better prediction of frost events could assist growers to proactively use irrigation, sprays, wind machines or helicopters to offer some protection of crops. Reducing the size of blocks can reduce wind impact, along with diversification of varieties to spread vulnerability across different periods. The Bay of Plenty may be able to learn from other regions that are exposed to frost events at present e.g., Central Otago.

Extreme rainfall and flooding

Approximately 34 km^2 of land area used for horticultural activities may be exposed to river and surface flooding either now or into the future (12.3% of total land area) (Figure 15.2 and Figure 14.3). Increased frequency of flooding may cause loss of crops, reduced productivity and yield. Extreme rainfall may increase erosion and cause slips resulting in nutrients being washed from the land (nutrient leaching). Kiwifruit and avocado orchards are highly sensitive to flooding, neither like wet roots.

Adaptation options include retrofitting orchards with pumps, using alternate harvesting equipment that can cope under boggy conditions e.g., tractors with tracks, maintaining ground cover under vines (by reducing use of glyphosate) to minimise bare earth which reduces run-off, and increasing water infiltration capacity (e.g. using ponds and swales).

Coastal flooding, erosion and groundwater rise and salinity stress

Approximately 27 km^2 of land area used for horticultural activities may be exposed to coastal flooding by late century (27 km^2 out of 277 km^2 total land area)(Figure 15.2 and Figure 14.3). Kiwifruit and avocado orchards dislike wet roots and exposure to salinity, although avocado trees have shallow roots and tend not to be planted in areas that are prone to flooding or salinity stress. Increased coastal flooding may cause the loss of coastal or peri-coastal orchards with high cost of damage or relocation.

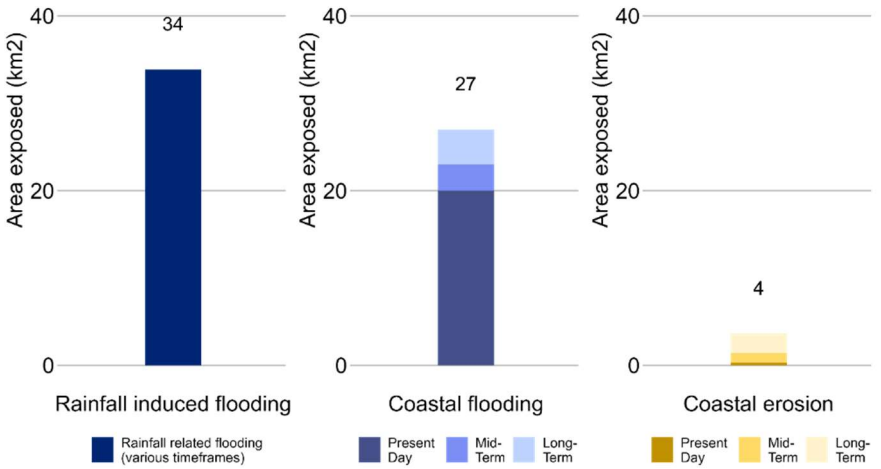


Figure 15.2: Land area of horticultural activity exposed to river and surface flooding and coastal hazards (277 km^2 total area)

Consequences

Consequences to horticulture arising from climate risks are summarised in Figure 15.3:

Social	Environmental	Economic	Cultural
• Uncertainty and stress for growers around changing climate hazards. • Competing land uses needing access to water can create tension within communities. • Increased risks to worker health and safety due to temperature extremes and increased use of chemicals.	• Increased use of chemicals resulting in environmental impacts. • Increasing demand for water. • Potential for mal-adaptation due to increasing electricity demands e.g., for cooling packhouses.	• Increasing costs to growers, due to adaptation measures, pesticides and other chemical applications, physical protection, relocation, and insurance. • Loss of income for growers due to reduced productivity and impacts on crop value	• Impacts on horticulture may have a high impact on Māori kiwifruit enterprise in the Eastern Bay

Figure 15.3: Summary of consequences from climate impacts to horticulture

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 15.2 identifies potential next steps for relevant stakeholders.

Table 15.2: Potential next steps for horticulture

Element at risk	Next steps	Interested / responsible parties
Horticulture	There could be value in pan-horticulture research to understand the contribution of climate change in altering climate characteristics that drive the risk profile of the industry. This could feed into a medium-term risk assessment (e.g., 2030) which may better capture the pace at which risks to horticulture may eventuate. This may also consider changes to adaptive capacity (such as expected restrictions to water access through forthcoming policy changes) and enable improved knowledge sharing to support industry wide adaptation.	Growers associations, BOPRC, Plant & Food, Ministry for Primary Industries, e.g., perhaps through MPI Sustainable Land Management and Climate Change (SLMACC)

16 Economic industries: Forestry

The Bay of Plenty forms part of the Central North Island (CNI) forestry block. This block is New Zealand's premier forestry and wood processing region. The CNI has New Zealand's largest wood supply and hosts major New Zealand sawn timber, pulp, and paper mills (Figure 16.1).

The highest rated risks to forestry relate to extreme weather, dryness and drought, landslides, coastal erosion, and groundwater rise and salinity stress. Figure 14.3 shows locations of forestry plantations throughout the region and their exposure to coastal flooding, coastal erosion, and river flooding. Table 16.1 shows risk ratings at a district / regional scale.

Table 16.1: Climate risk ratings for forestry

Risks to forestry						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Increasing landslides	Flat forests	🟢	🟢	🟢	🟡	🟠
	Steep forests	🟡	🟡	🟡	🟠	🟠
Increased fire weather		🟡	🟡	🟡	🟠	🟠
Extreme rainfall and flooding		🟢	🟢	🟢	🟡	🟠
Extreme weather		🟠	🟠	🟠	🟠	🔴
Dryness and drought		🟡	🟡	🟠	🟠	🔴
Higher temperatures		🟢	🟢	🟢	🟡	🟡
Coastal erosion		🟢	🟡	🟡	🟠	🟠
Groundwater rise and salinity stress		🟢	🟡	🟡	🟠	🟠

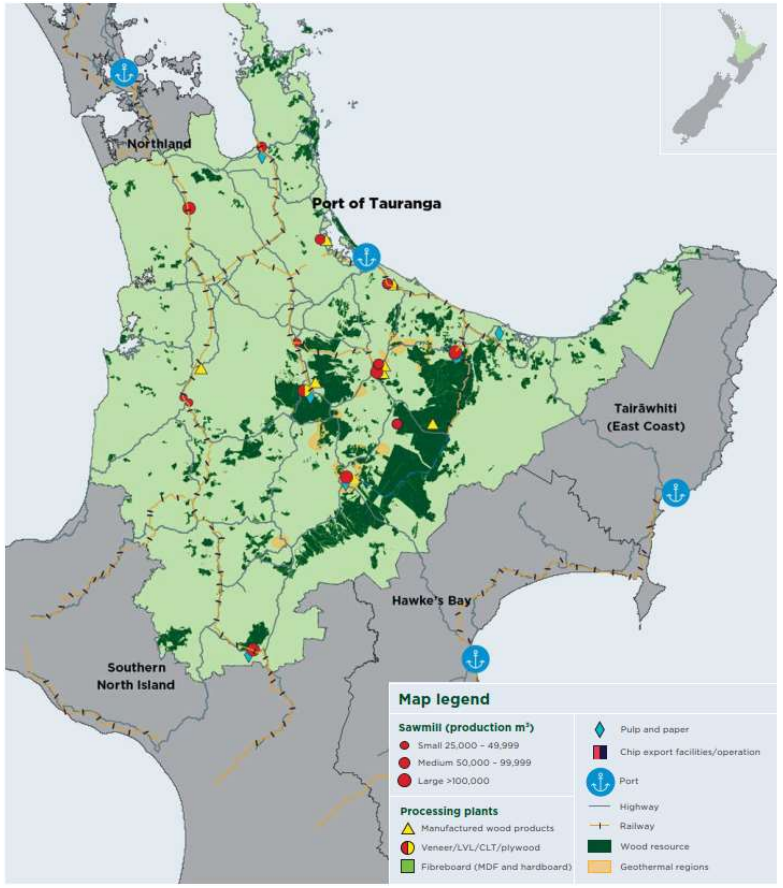


Figure 16.1: Central North Island wood supply region

Increasing fire weather

Fire risk in forests is inherently high but managed carefully. Sawmill facilities are located within Kaiangaroa (the largest forest) and contributes to fire risk but is well managed. Fire can cause devastating damage to plantations and have extremely high costs of damage. The

scale of fire is critical; crown fires (that are more intense and damaging) can occur in larger forests such as Kaiangaroa but are less likely to take hold in the mosaic of wood lots on farm sites interspersed with pasture that are common across the region.

Forestry operations have established strong adaptation processes to manage fire risk.

Increased extreme rainfall and flooding

Few forests are located in low lying areas (approximately 3km^2 region wide as shown in Figure 16.3). However, flooding can cause disruption of site access and along the supply chain to the Port, predominantly via rail, but some by truck. During harvesting, road access is important to maintain high quality logs, as they require removal within two to three days of felling to avoid being impacted by bacteria. This type of damage poses a significant financial risk.

Onsite management practices can be adapted to store logs appropriately if access is disrupted, e.g., water storage ponds may be established to keep logs onsite for longer periods of time.

Landslides

Soil loss resulting from high rainfall is an ongoing issue on steep slopes at present. Flatter forests, such the majority of Kaiangaroa, are less exposed to landslides, soil loss and erosion. The erosion potential of forests will increase as rainfall intensity and frequency increases. Forestry on steep slopes is sensitive to soil loss and erosion, particularly associated with roading and site preparation. Landslides can damage trees, cause high loss of land, and highly damaging debris flows.

Adaptive capacity includes sediment management practices to reduce soil loss. Other options for adaptation include reduced density of plantations or changing to drought tolerant species (e.g., eucalyptus thrives in dry conditions, although has a higher fire risk). However, there are commercial risks associated with changing species and operating in smaller markets where there tends to be lower demand.

Extreme weather (wind and storms)

Forests are highly sensitive to wind damage, which can snap trunks, or lead to tipping of trees if combined with rainfall. Wind can cause extensive damage to plantations, with damage occurring frequently throughout the country, e.g., a recent high wind event near Matea caused the loss of 200 ha of trees. A similar event is pictured in Figure 16.2. Plantations are most susceptible at mid rotation, from 12-13 years through to maturity. There are minimal avenues to adapt.



Figure 16.2: Windthrow damage near Reporoa (just outside BOP) resulting from a short duration high wind event in November 2020

Drought

Forestry is sensitive to reduced rainfall and drought which can affect the water holding potential in soil. Drought can cause tree stress resulting in heightened disease susceptibility, to which mono crops are inherently susceptible. Extended dry periods can have a negligible impact on productivity when intermittent but significant changes in seasonality/increased dryness or drought on a long term basis may impact groundwater holding potential, this can limit tree growth, degrade forest health, and result in reduced yield. Short term droughts/seasonality can be critical to the survival of trees during the planting and tree establishment phase (first 1-2 years) and can result in the loss of large numbers of seedlings. Dry out of forests contributes to fire risk due to fire. Reduced water availability may be problematic for processing as this requires large volumes of water.

Options for adaptation include reduced density of plantation or species change to drought tolerant species (e.g., eucalyptus thrives in dry conditions, though has a higher fire risk). However, there are commercial risks associated with changing species and operating in smaller markets for which there tends to be lower demand.

Temperature

Increasing temperature may impact worker wellbeing, however this is likely manageable (e.g., mitigated by shading from trees). The impact of temperatures on forest productivity is complex and the implications are unclear. Temperature contributes to increased fire risk, pests and diseases.

Coastal erosion

Rising groundwater, sea level rise and coastal erosion may damage coastal plantations, with exposure to coastal flooding affecting approximately 19 km^2 of mainland forestry plantation (Figure 16.3).

Coastal hazards are primarily an issue for Matakana Island, where there are 40 km^2 of productive and protective forests.

Coastal roads that are used to access East Coast forestry blocks may be damaged by erosion. There are few options to adapt, however the erosion threat to roads may be managed by improving or upgrading access or constructing alternative routes, however this is costly and complex.

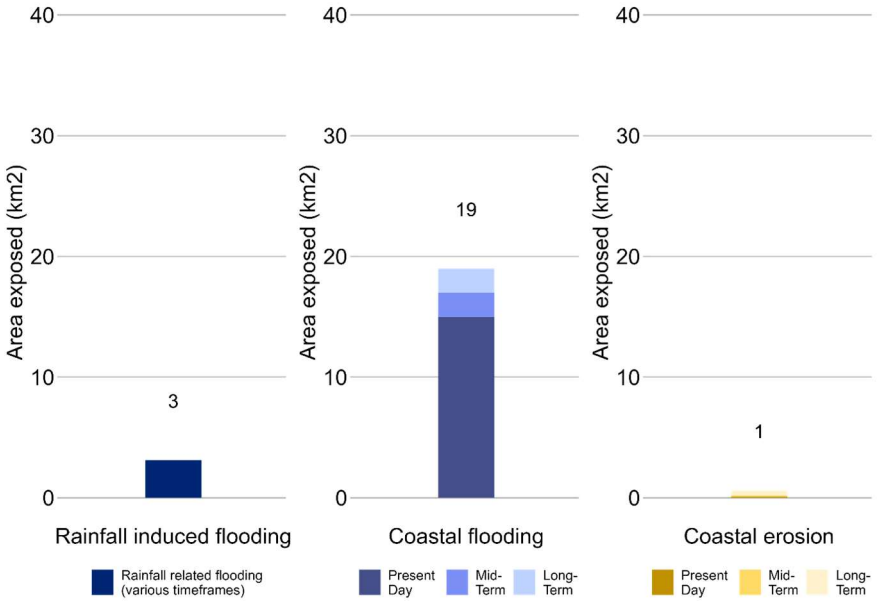


Figure 16.3: Land area of mainland forestry exposed to river and surface flooding and coastal hazards (note Matakana Island is excluded in modelling) (2471 km^2 total area)

Consequences

Consequences to forestry arising from climate risks are summarised in Figure 16.4.

Social	Environmental	Economic	Cultural
• Loss of coastal forests on Matakana Island would mean reduced shelter and protection against coastal hazards (storms, tsunami) for inland areas that are currently provided by the forests.	• Environmental impacts may arise from increasing forest fires: ecological damage, water quality impacts, increased stormwater runoff, more erosion, more atmospheric particulates (health and climate risks).	• Increasing cost of insurance may increase costs and could lead to reduced viability for some growers. • Reduced timber quality may result from many stressors / climate drivers, lower density, more poorly performing products, which may have wider impacts on the service value chain. • Damage to plantations may cause supply chain issues, loss of jobs, and high costs of remediation for growers.	• Impacts on forestry may have a high impact on Māori as there is high level of Māori ownership of forests.

Figure 16.4: Summary of consequences from climate impacts to forestry

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 16.2 identifies potential next steps for relevant stakeholders.

Table 16.2: Potential next steps for forestry

Element at risk	Next steps	Interested / responsible parties
Forests	Plantation specific assessment of climate risk could be undertaken to identify potential adaptation measures that may improve forest resilience.	Scion, New Zealand Forestry Owners Association, Forestry owners and operators
Forests	Regional collaboration and knowledge sharing may support better understanding of risks and climate adaptation.	Rotorua Climate Action Forum[16]

[16] Rotorua Climate Action Forum | RCAF https://www.rotoruaclimateaction.nz/

17 Economic industries: Fisheries

Fisheries in the Bay of Plenty support the regional economy. There are three oyster farms in the Bay of Plenty approximately two hectares each in size located in Ōhiwa Harbour. Approval for a 3,800 hectare marine farm offshore from Ōpōtiki the largest marine farm in New Zealand, was granted by the Minister of Conservation in February 2008. Since then, commercial mussel farming has been established by Whakatōhea Mussels (Opotiki) Limited and four other companies. This includes lines in the water for spat catching and on growing to harvestable mussels. Green-lipped mussels are grown on lines suspended from floats on the surface, while Pacific oysters are grown on intertidal racks.

The region has a strategy to grow the sustainable aquaculture industry[17] and the industry is in a period of growth, particularly through initiatives of local iwi/Māori (e.g., Nga Iwi i te Rohe o Te Waiariki & Whakatohea Māori Trust Board). The regional strategy identifies a focus area on exploring new opportunities in aquaculture, including farming of new species, new technology and the use of geothermal energy sources for land-based aquaculture. Expansion of the region's aquaculture industry into new species is under investigation, particularly pacific oysters (Tio), flat oysters (Tio para), and geoduck (Hohehoe)[18]. Within New Zealand, the main commercial species farmed are green-lipped mussels and pacific oysters. Other species farmed include salmon, paua, snapper and kingfish.

The highest rated risks to fisheries relate to marine heatwaves, ocean acidification and increasing temperature of freshwater habitats, sedimentation, and sea level rise. Table 17.1 shows risk ratings at a regional scale.

Table 17.1: Climate risk ratings for fisheries

Risks to fisheries						
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
		Now	2050	2050	2100	2100
Marine heatwaves and ocean chemistry changes	Aquaculture (inshore)					
	Aquaculture (marine)					
	Wild fisheries					
	Freshwater					
Sedimentation	Aquaculture (inshore)					
	Aquaculture (marine)					
	Wild fisheries					
	Freshwater					
Sea level rise and coastal flooding	Aquaculture facilities and infrastructure					
	Recreational fishing					

[17] Bay of Connections (2013) Bay of connections aquaculture strategy 2013

[18] Ōpōtiki District Council (2017) Ōpōtiki Harbour Transformation Project, Workstream 15: Supporting Innovation. Summary Report of Opportunity Assessment and Expert Review Findings

Marine heatwaves and ocean chemistry changes

Marine heatwaves and ocean chemistry changes may increase water temperature beyond optimum conditions for aquaculture and fisheries, due to reduced dissolved oxygen, increased parasites and changing oceanographic patterns. This can lead to reduced economic and biological viability of aquaculture. It may also lead to the collapse of food webs and coastal productivity, with consequences for aquaculture and fisheries, particularly wild catch. The sensitivity of fisheries varies by farming activity, with shellfish known to be highly sensitive to ocean acidification.

The aquaculture industry has a high capacity to adapt. There is potential to shift to farming species with lower sensitivity e.g., seaweed, or move activities further offshore or further south to cooler locations. Wild catch farming is much less adaptable, as it is highly dependent on natural ecosystems, which are at high risk.

Freshwater sports fisheries relate primarily to rainbow and brown trout. Salmonids are highly temperature sensitive, with trout the most tolerant of the salmonid species. Trout within the Bay of Plenty are observed to be stressed at present with declining populations. The adaptive capacity of freshwater sports fisheries is low, however there may be potential for the introduction of alternative temperature tolerant species.

Extreme rainfall and flooding

Flood flows cause fine sediment and mud to be winnowed out of shallow subtidal zones and muddy plumes to be discharged from rivers. Sensitivity of fisheries varies by farming activity. Shellfish are highly sensitive to runoff from agricultural land use as they can take up contaminants in sediment making them inedible due to bacteria levels. This can require restrictions on harvest following rainfall. Seaweed growth can be highly sensitive to obstruction of light due to sediment. Wild species, including pelagic fish (e.g., skipjack tuna, mackerel), snapper and kahawai, scallop, crayfish and spat capture are highly sensitive to sediment deposition and related impacts on the wider ecosystem.

In freshwater environments, trout are also sensitive to reduced water quality resulting from increased sediment and nutrients in waterways.

Aquaculture activities tend to have potential to adapt farming activity and location to respond to changing conditions in the longer term. Wild catch could adapt by changing the species of catch in response to changing populations, however this is uncertain and may be constrained by the quota management system.

Sea level rise, coastal flooding and extreme wind and storms

Sea level rise and coastal flooding may damage aquaculture and fishery related facilities or infrastructure, preventing normal operation of related businesses in coastal areas. Most facilities are designed to withstand high swells and are insured. However, increasing exposure may cause increased damage with resultant increases in insurance and cost of production, potentially discouraging investment. Permanent nearshore structures tend to be located in low-lying areas and may experience increased damage and reduced capacity to manage effluent.

Adaptive management approaches include changing the orientation of mussel lines; however some approaches are expensive (e.g. relocation of facilities) or constrained by existing consent conditions.

Consequences

Consequences arising from climate risks to fisheries are summarised in Figure 17.1.

Social	Environmental	Economic	Cultural
• Reduced quality in fish could lead to health implications for humans. • Reduced food security, particularly in relation to recreational and customary fisheries, which could lead to further inequity as food prices may rise.	• None identified	• Impacts to aquaculture can lead to economic and employment impacts.	• Impacts to kaimoana can affect cultural identity and could lead to further inequality due to kaimoana being the only source of food for some communities. • Cultural identity can be impacted, particularly if complete ecosystems or native species are damaged/killed. • Aquaculture farms are a major interest for iwi in the region, with wider consequences to iwi if these are impacted.

Figure 17.1: Summary of consequences from climate impacts to fisheries

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 17.2 identifies potential next steps for relevant stakeholders.

Table 17.2: Potential next steps for fisheries

Element at risk	Next steps	Interested / responsible parties
Commercial fisheries (including aquaculture)	Activity specific assessment of climate risk to the fisheries sector could be undertaken to support adaptation and enable the sector to respond to the changing environment. This could support further work in exploring the need for adaptive consent conditions and adjustment to fisheries quotas, both of which can be lengthy processes to engage with.	Fisheries sector commercial operators, Seafood NZ, Aquaculture NZ, Ministry for Primary Industries.

18 Archaeological sites

The Bay of Plenty has extensive coverage of archaeological sites. These relate to both pre-European Māori settlement and later colonial settlement. Iwi/Māori perspectives on climate risk are discussed in Volume 1. Archaeological sites and coastal and riverine floodplains are shown in Figure 18.1.

The highest rated risks to archaeological sites relate to coastal erosion and river and surface flooding as shown in Table 18.1.

Table 18.1: Climate risk ratings for archaeological sites

Risks to archaeological sites					
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	Now	2050	2050	2100	2100
Coastal erosion					
Groundwater rise and salinity stress					
SLR and coastal flooding					
Increased extreme rainfall and flooding					

Coastal hazards

Coastal areas are highly important historical locations and tend to have high numbers of historical features, some of which are already exposed to damage. For example, cliff faces in the Western Bay currently have a high number of sites that are impacted. Assessment of the exposure of archaeological sites to coastal erosion indicates 7% of recorded archaeological sites within the region are exposed to the 1% AEP[19] coastal inundation event at present, increasing to 12% by late century (Figure 18.1).

Archaeological sites are highly sensitive to coastal erosion, posing a threat to the integrity of these sites with potential to erode and destroy fragile historical features such as middens, terraces and pa.

Increased extreme rainfall and flooding

River and surface flooding can cause erosion, which poses a similar threat to archaeological sites as coastal hazards. Low levels of damage to sites due to erosion and flooding is already occurring, with flood plain mapping indicating up to 30% of archaeological sites may be exposed to river and surface flooding (Figure 18.1).

Adaptation to flooding and coastal hazards

Archaeological sites have a very low capacity to adapt, options include protection or relocation/salvage. Relocation of cultural sites can be highly traumatic for the affected community.

[19] An annual exceedance probability (AEP) is the probability of an event occurring in any given year e.g. a 1% AEP means there is a 1% chance in any given year of the event occurring.

Archaeological Site Exposure

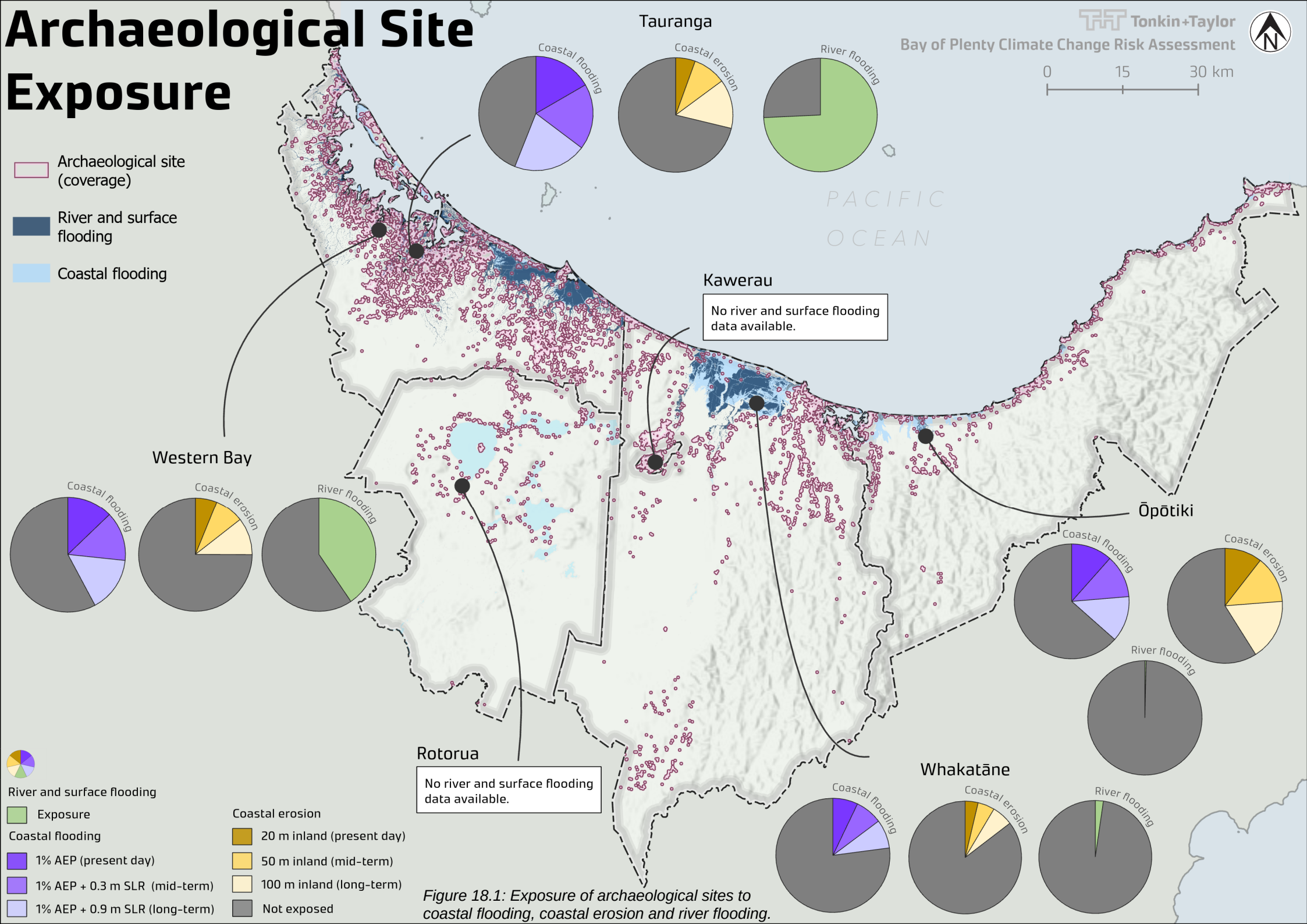


Figure 18.1: Exposure of archaeological sites to coastal flooding, coastal erosion and river flooding.

Consequences

Consequences arising from climate risks to archaeological sites are summarised in Figure 18.2.

Social	Environmental	Economic	Cultural
• Loss of archaeological sites may result in a loss of cultural history, resulting in a loss of sense of place and belonging.	• None identified	• Loss of cultural heritage may result in impacts on tourism.	• Cultural sites are highly important to Māori. Damage or loss of these sites can be extremely traumatic for affected communities.

Figure 18.2: Summary of consequences from climate impacts to archaeological sites

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 18.2 identifies potential next steps for relevant stakeholders.

Table 18.2: Potential next steps for archaeological sites

Element at risk	Next steps	Interested / responsible parties
Archaeological sites	Detailed climate risk assessment of archaeological sites may enable identification of sites that are most at risk and require protection or relocation.	Heritage NZ, BOPRC, Department of Conservation and iwi.

19 Health and wellbeing

Climate change poses risks to health and wellbeing across the region. Those who reside at the coastal fringe will be the most likely to be exposed to sea level rise and storm surges, and those in low-lying or flood prone areas will be most likely exposed to harm from flooding. The largest temperature increases are projected to occur in coastal areas and inland along the Rangitāiki River valley. These areas may also be exposed to increased fire risk and drought.

Climate change impacts on physical health can be through direct exposure to hazards or indirect consequences arising from climate related impacts across the region. These can occur as either acute (e.g., injury from fire or during a storm) or chronic (e.g., long term impacts on wellbeing). The risks outlined in this assessment are drawn from the Hauora a Toi Bay of Plenty Climate Change Risk assessment (2022).

Direct risks to health

Direct risks to health include risks arising from temperature, fire weather, drought, extreme rainfall and flooding and groundwater rise.

Temperature

Higher temperatures can impact health, particularly in kaumatua, ageing and other vulnerable groups. Higher temperatures can increase the frequency of heat related illness such as dehydration, heat stroke, sunburn, respiratory conditions, injuries from accidents from water activities, increased instances of violence, and increased mortality in those with cardiovascular and respiratory diseases. Higher temperatures may also result in increased duration of pollen production (due to a longer growing season), with consequential impacts on allergy sufferers.

Fire weather

Increasing fire weather poses a direct risk to life from fire weather, including injury or death, and respiratory conditions (from ash).

Drought

Drought conditions can lead to water shortages, which can result in the following impacts: dehydration, the inability to complete safe hygiene practises, infectious diseases and nutritional deficiencies that come from a lack of food availability. There are also a range of risks to commercial water users, which lead to impacts on people's well-being (e.g., increased costs).

Extreme rainfall and flooding

Increased rainfall can lead to flooding events which can increase the frequency of drowning, injury, waterborne diseases, declined community health from increased contaminants in the water, loss of property, loss of livelihood, homelessness, stress, reduced access to care (including emergency services) and psychosocial stress.

Groundwater rise

Groundwater rise (that can occur as a result of sea level rise) can lead to dampness around houses which can lead to negative health impacts such as, Rheumatic fever, School sores and Asthma.

Groundwater rise may also lead to an increase in the presence of mosquitoes which can result in more vector-borne diseases.

Consequences and indirect risks to health

Indirect impacts on health include issues such as those arising from worsening water availability and quality, temperature related and vector-borne diseases, supply chain disruption, air quality deterioration, and lifestyle and behavioural changes. Indirect impacts on health are mediated by a complex interaction of social, environmental, and economic factors.

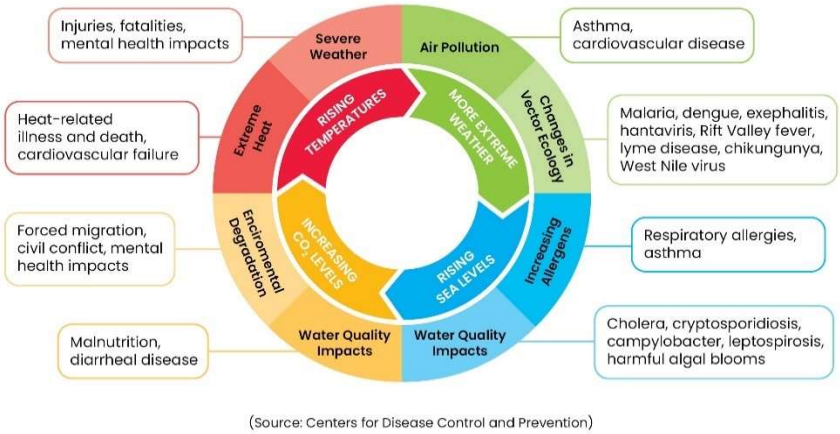


Figure 19.1: Impacts of climate change on human health (source: te Whatu Ora, 2022)

Indirect risks can manifest through multiple impact pathways and cascades. For example, increasing temperature can lead to a variety of first order impacts which can cause a range of second order impacts as shown in Figure 19.2.

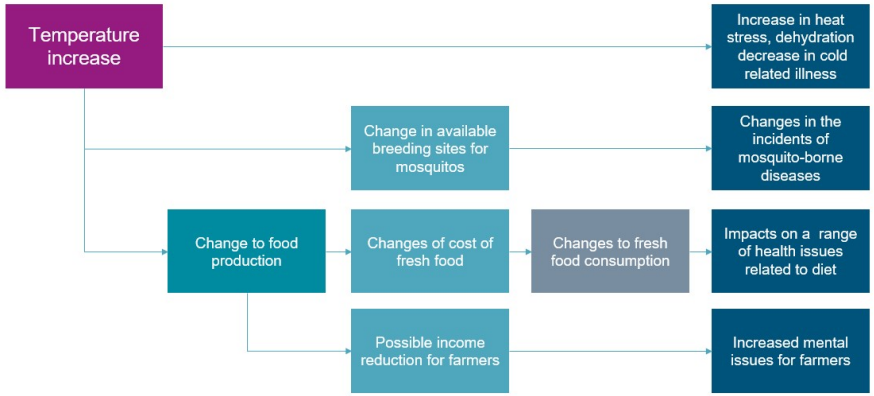


Figure 19.2: Temperature-related impact pathways on health

Mental health impacts may arise from a range of climate change related factors, including event related trauma such as from floods or storms, slow onset physical hazards, environmental degradation, erosion 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 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, 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 Volume 1). 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 (as shown in Volume 1). 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 socially deprived 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.

Next steps

This assessment provides risk information that can inform adaptation planning for relevant sectors and stakeholders. It can also provide a foundation for further detailed assessments of the specific at-risk locations, where required, that may inform specific adaptation responses. Table 19.1 identifies potential next steps for relevant stakeholders.

Table 19.1: Potential next steps for health

Element at risk	Next steps	Interested / responsible parties
BOP public health	The risks outlined in this section are drawn from the BOP DHB climate change risk assessment (March 2022). Te Whatu Ora Health New Zealand are in the process of confirming the next steps to support climate adaptation for the health sector across the region.	Te Whatu Ora & Ministry of Health

20 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.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
.....	.....
Katherine Cowper-Heays	Peter Cochrane
Water and climate resilience consultant	Project Director

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