Bioeconomy Science Institute™
MANAAKI WHENUA – LANDCARE RESEARCH GROUP

Ngā mea hirahira o te ao Māori: Climate change risks to the Māori domain, National Climate Change Risk Assessment (NCCRA) 2026

Revised May 2026

Ngā mea hirahira o te ao Māori: Climate change risks to the Māori domain

National Climate Change Risk Assessment (NCCRA) 2026

Prepared for: He Pou a Rangi – Climate Change Commission

November 2025

Shaun Awatere, Nikki Harcourt, Ani Kainamu, Margaret Forster

Manaaki Whenua – Landcare Research, a group of the Bioeconomy Science Institute

Bridgette Masters-Awatere

University of Waikato

Contract Report registration number: 2526-0040

Revised May 2026, reference list corrections applied

Disclaimer

This report has been prepared by the New Zealand Institute for Bioeconomy Science Limited for the He Pou a Rangi – Climate Change Commission. If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information in it.

Reviewed by:

Dean Stronge
Researcher – Environmental Social Science
Bioeconomy Science Institute

Dan Richards
Senior Researcher – Landscape Ecology & Research Priority Leader
Bioeconomy Science Institute

Approved for release by:

Melissa Robson-Williams
Portfolio Leader – Catalysing Change
Bioeconomy Science Institute

Contents

Summary v
1 Project and client 1
2 Methodology 2
2.1 Approach 2
2.2 Open AI use 3
2.3 Report structure and notes on repetition 4
3 Part 1: Risk severity 5
3.1 Loss of access to taonga species 9
3.2 Damage to Māori infrastructure 24
3.3 Economic losses in primary industries 35
3.4 Disruption to tikanga and hapū/iwi identity 50
3.5 Loss of indigenous knowledge systems 62
3.6 Legal exclusion and governance failures 73
3.7 Increased health vulnerabilities 84
4 Part 2: Policy readiness 100
4.1 Outline of Pt 2 approach, structure and methods 100
4.2 Loss of access to taonga species 104
4.3 Damage to Māori infrastructure 111
4.4 Economic losses in primary industries 117
4.5 Disruptions to tikanga and hapū/iwi identity 123
4.6 Loss of Indigenous knowledge systems 129
4.7 Legal exclusion and governance failures 135
4.8 Increased health vulnerabilities 140
5 Part 3: Summary of policy readiness 147
5.1 Loss of access to taonga species 147
5.2 Damage to Māori infrastructure 147
5.3 Economic losses in primary industries 147
5.4 Disruptions to tikanga and hapū/iwi identity 147
5.5 Loss of Indigenous knowledge systems 148
5.6 Legal exclusion and governance failures 148
5.7 Increased health vulnerabilities 148
6 Acknowledgements 149
7 References 150
Glossary of Māori words/concepts (kupu Māori) 164
Glossary of initialisms and acronyms 168

© New Zealand Institute for Bioeconomy Science Limited (2026)

List of Tables

Table 1: Risk severity scores under different climate scenarios for all risks in the te ao Māori domain 7
Table 2: Summary table for the risk of loss of access to taonga species 9
Table 3: Loss of access to taonga species risk severity criteria 21
Table 4: Risk severity scores under different climate scenarios for loss of access to taonga species 23
Table 5: Summary table for the climate risk of damage to Māori infrastructure 24
Table 6: Risk to Māori Infrastructure risk severity criteria 32
Table 7: Risk severity scores under different climate scenarios for Māori infrastructure 34
Table 8: Summary table for the climate risk of economic losses in primary industries 35
Table 9: Economic losses in Māori primary industries risk severity criteria 47
Table 10: Risk severity scores under different climate scenarios for economic losses in Māori primary industries 49
Table 11: Summary table for the climate risk of disruption to tikanga and hapū/iwi identity 50
Table 12: Disruptions to tikanga and hapū/iwi identity risk severity criteria 59
Table 13: Risk severity scores under different climate scenarios for disruptions to tikanga and hapū/iwi identity 61
Table 14: Summary table for the climate risk of loss of Indigenous knowledge systems 62
Table 15: Loss of indigenous knowledge systems risk severity criteria 70
Table 16: Risk severity scores under different climate scenarios for loss of Indigenous knowledge systems 72
Table 17: Summary table for the climate risk of legal exclusion and governance failures 73
Table 18: Legal exclusion and governance risk severity criteria 81
Table 19: Risk severity scores under different climate scenarios for legal exclusion and governance 83
Table 20: Summary table for climate risk and increased health vulnerabilities 84
Table 21: Increased health vulnerabilities risk severity criteria 97
Table 22: Risk severity scores under different climate scenarios for increased health vulnerabilities 99
Table 23: Policy readiness criteria (based on different dimensions) – used to evaluate the likely policy readiness for risk 102
Table 24: Assessment of policy readiness for all risks 103
Table 25: Policy readiness assessment for loss of access to taonga species risk 110
Table 26: Policy readiness assessment for damage to Māori infrastructure 116
Table 27: Policy readiness assessment for economic losses in primary industries risk 122
Table 28: Policy readiness assessment for disruptions to tikanga and hapū/iwi identity 128
Table 29: Policy readiness assessment for loss of Indigenous knowledge systems 134
Table 30: Policy readiness assessment for legal exclusion and governance failure 139
Table 31: Policy readiness assessment for increased health vulnerabilities 146

© New Zealand Institute for Bioeconomy Science Limited (2026)

Summary

This report supports the 2026 *National Climate Change Risk Assessment* (hereafter, NCCRA) by identifying the highest-priority climate-related risks for Māori. Grounded in earlier (2021) work by Awatere et al., it provides a kaupapa Māori[1]-informed lens on national climate risks for the Ngā mea hirahira o te ao Māori: Climate Change Risks to the Māori domain in the NCCRA.

We used a qualitative content analysis approach to assess and expand on several factors for describing risks systematically, including exposure and sensitivity, adaptive capacity, compounding factors, socioeconomic trends, climate thresholds and tipping points, interactions with mitigation actions, data gaps, confidence level and overall risk rating. A support-then-expand method guided the review, where existing statements were supported with new references from Māori-led research and National Science Challenge (NSC) outputs. We added new content only where apparent gaps existed, and particularly where uniquely Māori risks were under-represented. Māori researchers reviewed all outputs to ensure alignment with a te ao Māori[1] perspective and a cautious tone.

We assessed seven interrelated risks to Māori as being of high severity in the present day and likely to escalate over time, reaching a level of extreme severity under high-emissions scenarios by 2090. The risk trajectories differ depending on emissions pathways and the scale of institutional reform, but without Te Tiriti (Treaty of Waitangi)[1]-consistent adaptation, intergenerational impacts are likely to deepen. The seven risks are shown below.

1 **Loss of access to taonga species**
Species decline, habitat loss, and regulatory exclusion threaten mahinga kai (food gathering places)[1], seasonal knowledge (maramataka),[1] and tikanga (cultural)[1] practices rooted in specific ecosystems. While some restoration efforts maintain viability in parts of Aotearoa New Zealand (hereafter, 'Aotearoa')[1] today, climate and land-use pressures are projected to severely restrict access by 2050, with near-irreversible collapse of key taonga (cultural keystone) species[1] populations in some rohe (iwi/hapū regions)[1] by 2090 under high emissions. This makes taonga species loss one of the most severe risks identified.

2 **Damage to Māori infrastructure**
Marae,[1] urupā (burial sites)[1], and papakāinga (housing on ancestral land)[1] face increasing exposure to flooding, coastal erosion, and wildfires. Many sites are uninsured and excluded from adaptation planning frameworks. By mid-century, repeated events are expected to disrupt infrastructure function, with cumulative and potentially irreversible loss of marae and papakāinga projected by 2090, leading to long-term cultural fragmentation.

3 **Economic losses in primary industries**
Māori-owned forestry, farming, aquaculture, and horticulture enterprises are vulnerable to multiple climate hazards. Underinvestment in rural infrastructure and lack of access to risk-sharing mechanisms compound these risks. Near-term disruptions (to 2050) are likely to increase costs and financial stress. By 2090, sustained climate stress and underinvestment may result in systemic economic decline and business closures unless transformative reforms are implemented.

4 **Disruption to tikanga and hapū/iwi identity**
Relocation and managed retreat both threaten spiritual connections, identity, and intergenerational well-being, especially where ahi kā (continuous occupation)[1] and whakapapa

[1] A full glossary of te reo Māori words and place/organisation names is provided at the end of this report.

© New Zealand Institute for Bioeconomy Science Limited (2026)

(lineage/connection)[1] to place are central. Present-day impacts remain localised. However, by mid-century, ecological degradation and displacement will increasingly undermine tikanga transmission, with widespread risk of cultural disconnection by 2090, particularly when ecosystems or ancestral lands are no longer accessible.

5 **Loss of Indigenous knowledge systems**
Climate change disrupts mātauranga Māori[1] and its transmission, particularly where species loss and institutional barriers prevent tikanga from being practised or taught. Although revitalisation efforts are active now, environmental disruption and weak integration into education and governance systems are expected to accelerate knowledge loss by mid-century, leading to systemic collapse of intergenerational knowledge transfer in high-emissions 2090 scenarios.

6 **Legal exclusion and governance failures**
Māori are often marginalised in climate governance. Te Tiriti obligations, collective tenure systems, and Indigenous authority are poorly recognised in current policy and planning. While participation is improving in pockets today, systemic exclusion persists. By 2050, the lack of statutory authority for Māori is likely to erode institutional legitimacy and trust, with risks escalating to systemic governance failure if Māori remain excluded as climate risks intensify by 2090. We consider this one of the most severe risks, compounding all the others.

7 **Increased health vulnerabilities**
Māori communities face heightened risk due to substandard housing, poor water access, and limited healthcare, particularly wāhine Māori,[1] kaumātua (older people)[1], and those in remote areas. By 2050, health inequities are projected to widen through increased exposure to infectious diseases, mental health stress, and loss of marae-based care systems. Without Māori-led planning and sustained investment, by 2090, health governance may face systemic overload and intergenerational harm.

These risks highlight the urgency of taking Māori-led, place-based, and mana motuhake[1]–affirming adaptation responses. However, we assess policy readiness for this as weak. We rate five risks (to taonga species, Māori infrastructure, tikanga/identity, Indigenous knowledge systems, and governance failures) as “Insufficient” overall in this report, while economic losses and health vulnerabilities are rated as “Significant” gaps overall. Policy levers are fragmented, often indirect or enabling rather than direct, and most lack the scale and urgency required to ameliorate our projected risk trajectories. Even if all existing policies were implemented, residual risks for Māori communities would remain severe and disproportionately high.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Noho tahanga a Papatūānuku, kia whakakorowai i a ia

Our Earth Mother lies bare, let us cloak her in a rich tapestry

of biological diversity to restore her energy and vibrancy

Keita Ngata

© New Zealand Institute for Bioeconomy Science Limited (2026)

1 Project and client

He Pou a Rangi – Climate Change Commission[2] (hereafter, "The Commission") aims to build the evidence base for the second National Climate Change Risk Assessment (NCCRA),[3] due by August 2026. The NCCRA will prioritise adaptation efforts and policies by systematically assessing the risks climate change poses to Aotearoa New Zealand's economy, society, environment, and ecology. It will inform the Government's National Adaptation Plan (NAP). The Commission will engage with various stakeholders, particularly seeking community-level perspectives.

The Commission aims to enhance the integration of te ao Māori[2] and mātauranga Māori[2] in the 2026 NCCRA. This includes incorporating Ngā mea hirahira o te ao Māori as a domain within the Assessment and addressing risks to Māori interests, health, culture, and practices from climate change in other domains, as shown in Figure 1.

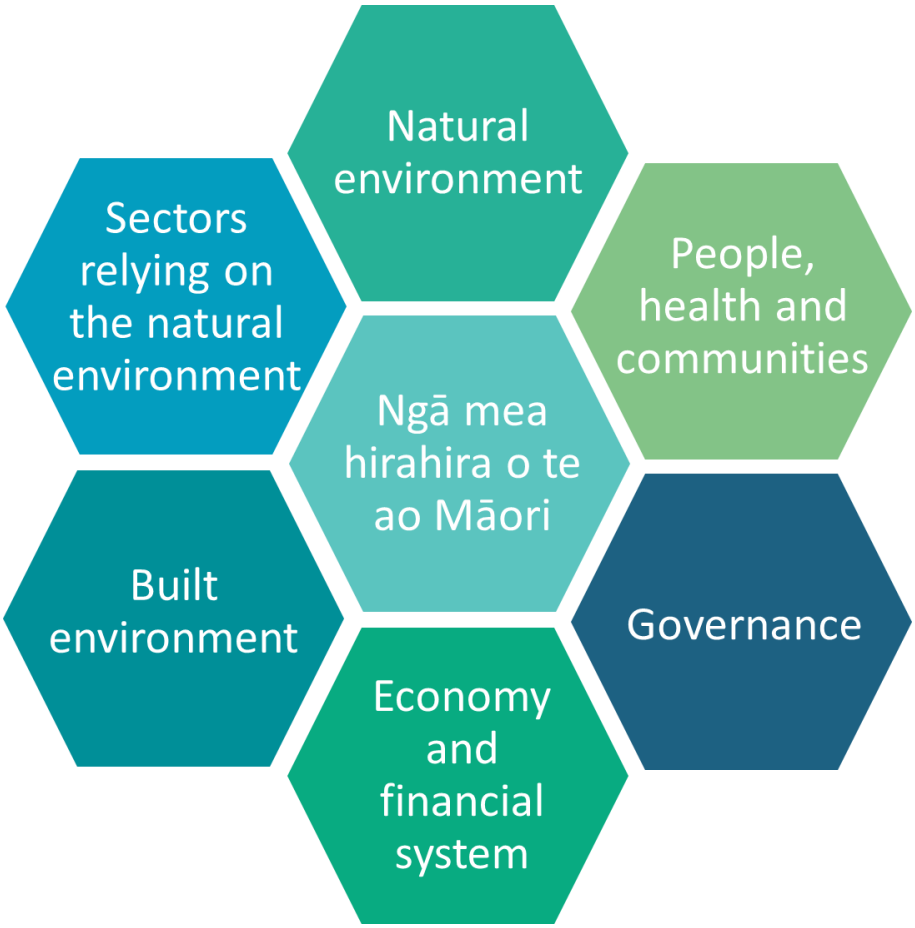

Figure 1: Domains being included in the 2026 NCCRA (Source: The Commission).

[2] A full glossary of te reo Māori words and place/organisation names is provided at the end of this report.

[3] A short glossary of initialisms and acronyms is provided at the end of this report.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Manaaki Whenua – Landcare Research[4] and Ngā Pae o te Māramatanga were contracted by the Commission to identify and assess risks in the Ngā mea hirahira o te ao Māori domain (hereafter known as the "te ao Māori domain") for the 2026 NCCRA. This included reviewing recent evidence since 2021, aligning findings with the Commission's risk assessment framework, and ensuring integration across other domains. The research team were also asked to workshop and prioritise identified risks. Within the te ao Māori domain, all this work was to culminate in a report (i.e. this current report) that would then form the basis of the assessment for this domain.

2 Methodology

Our assessment synthesises evidence from several sources, including peer-reviewed journal articles, Waitangi Tribunal submissions, academic reviews, and government reports. Documents about the impacts of climate change on Māori were prioritised and selected as key materials. Many documents were drawn from these six major National Science Challenges (NSCs) and their aligned research programmes: Biological Heritage (BioH), Deep South Challenge (DSC), Resilience Challenge, Sustainable Seas, Building Better Homes, Towns and Cities (BBHTC), and Our Land and Water (OLW).

2.1 Approach

The methodology draws on a qualitative content analysis approach (Schreier 2012), structured by the risk assessment framework established in Part One of the *National Climate Change Risk Assessment (NCCRA)*. Each risk was assessed using the NCCRA's standardised template, which includes the following elements:

- risk severity
- exposure and sensitivity
- adaptive capacity
- compounding factors
- socioeconomic trends
- climate thresholds and tipping points
- interactions with mitigation actions
- data gaps
- confidence levels
- an overall risk rating.

[4] On 01 July 2025 Landcare Research New Zealand Ltd became the New Zealand Institute for Bioeconomy Science Ltd; Manaaki Whenua – Landcare Research currently operates as an internal group within this Institute, which is less formally known as the Bioeconomy Science Institute (BSI).

© New Zealand Institute for Bioeconomy Science Limited (2026)

The seven Māori-specific risks were identified in Awatere et al. (2021), which offered a kaupapa Māori framing that informed the original NCCRA process. These risks are listed below.

1 Loss of access to taonga species.

2 Damage to Māori infrastructure.

3 Economic losses in primary industries.

4 Disruption to tikanga and hapū/iwi identity.

5 Loss of Indigenous knowledge systems.

6 Legal exclusion and governance failures.

7 Increased health vulnerabilities.

Our analysis followed a “support-then-expand” approach, which is outlined in the following bullets.

- An initial content analysis was reviewed and strengthened with evidence from additional sources.
- New content was added only where the original text lacked coverage of emerging issues or unique Māori perspectives.
- Statements were moderated to ensure accuracy, avoid overstatement, and maintain alignment with both the NCCRA's tone and kaupapa Māori values from Awatere et al., 2021.

2.2 Open AI use

We used ChatGPT Version 5 (OpenAI 2025) as a language support tool to increase analytical efficiency (see “Declaration of the use of generative AI/AI-assisted technologies” in Section 6). The use included generating draft summaries of long documents, identifying content relevant to NCCRA risk components, suggesting supplementary citations to support/expand risk statements, ensuring narrative consistency across sections, and moderating tone and phrasing.

Our use of Chat GPT was supported by emerging research on machine learning tools in evidence synthesis, which shows that such tools can streamline document review and assist in identifying relevant material without replacing human oversight (Marshall & Wallace 2019).

The process we followed for the use of AI aligns with findings from the UK Department for Science, Innovation and Technology (2024), which demonstrated that AI-assisted reviews can significantly increase efficiency without compromising quality when paired with human expertise. All ChatGPT-generated content was reviewed, edited, and approved by researchers with domain knowledge in climate adaptation, Māori governance, and environmental risk. The tool was not used for evaluative judgments or policy recommendations but supported productivity, consistency, and clarity.

© New Zealand Institute for Bioeconomy Science Limited (2026)

2.3 Report structure and notes on repetition

The report is presented in three parts. Part 1 covers Risk severity, with subsections dealing with each of the seven identified risks to Māori. Part 2 covers Policy readiness, again with subsections.

The repetition of specific themes and impacts across risk categories in this assessment report reflects the entangled and relational nature of Māori environmental world views. Rather than signalling duplication, these overlaps highlight how single events or stressors, such as species loss or ecosystem degradation, cascade through multiple domains of well-being, governance, health, identity, and economic life.

Where appropriate, these interconnections have been preserved to honour a whakapapa-informed approach to climate risk and to reflect the lived experience of compounding impacts. Because each risk is assessed using a common template (see Appendix 1: NCCRA analytical template, Appendix 2: NCCRA risk severity rating criteria exemplar, Appendix 3: NCCRA overall risk severity ratings template and Appendix 4: Policy readiness scorecard template), some sources and formulations recur across sections. This is intentional: it preserves comparability, lets each section stand alone, and maintains traceability of evidence across shared drivers, rather than duplicating analysis for its own sake.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3 Part 1: Risk severity

Indigenous peoples, including Māori in Aotearoa New Zealand (hereafter “Aotearoa”), face significant climate change risks affecting their culture, economy, environment, legal rights, and health. These include the loss of important keystone species, threats to livelihoods in primary industries, worsened health inequities, erosion of hapū/iwi identity tied to land and language, and challenges to tino rangatiratanga due to legal and governance failures. To better understand the scale and progression of these interconnected risks, the authors of this report have undertaken a structured assessment across multiple climate scenarios.

Table 1 presents an integrated summary of projected risk severity scores for seven climate-related risks specifically affecting Māori communities across four climate scenarios identified by the Commission: present day, 2050 (1.5°C–2°C warming), 2090 under Global Warming Level 2 (GWL 2; low emissions), and 2090 under Global Warming Level 3–3.5 (GLW 3–3.5; high emissions). These severity scores were developed by synthesising the published literature for the past 5 years related to the climate change impacts on Māori. This approach to risk severity scoring utilised the Commission’s templates (see Appendix 2 and 3) and was adapted for each risk in the te ao Māori domain. The assessment reflects both biophysical exposure and structural drivers of vulnerability, such as governance exclusion, housing inequities, and underinvestment in Māori-led solutions, allowing for a more holistic understanding of systemic risk to Māori, their environment and culture (hereafter, the “te ao Māori domain”).

Each risk score reflects expert judgement by the authors of this report on the likely consequence level at a given warming threshold. Judgements were based on evidence of current te ao Māori capacity, projected climate impacts, and the degree to which Māori rights, knowledge, and adaptive practices are embedded in governance, infrastructure, and ecological systems. The scores assume current policy trajectories remain unchanged, unless specified, and highlight where emissions pathways and institutional responses will strongly influence future outcomes.

The following bullets summarise key insights from Table 1.

- All seven risks increase in severity across time and climate scenarios, with all seven reaching extreme levels by 2090 under a high-emissions trajectory. This signals that the te ao Māori domain is highly sensitive to climate stress, particularly when institutional conditions remain unchanged.
- Legal exclusion and governance failures, increased health vulnerabilities, and loss of access to taonga species all show a high likelihood of cascading, systemic effects without structural reform, primarily where Māori governance is not supported through resourcing, mandate, or data sovereignty.
- Disruptions to tikanga and hapū/iwi identity and the loss of Indigenous knowledge systems display intergenerational consequences linked to the degradation of keystone species and loss of place-based practice. The severity of these risks intensifies when climate impacts overlap with exclusion from research, planning, and education.
- Economic losses in Māori primary industries and damage to Māori infrastructure both reflect compound risk profiles, where physical climate hazards are exacerbated by systemic underinvestment and inadequate alignment of national funding and planning tools with tikanga-based models.
- Despite regional variation, Table 1 demonstrates that all risks are highly sensitive to both climate and institutional pathways. This points to the urgent need for tailored adaptation

© New Zealand Institute for Bioeconomy Science Limited (2026)

responses that are not only technically effective but grounded in Te Tiriti o Waitangi and te ao Māori approaches.

Sections 3.1–3.7 provide further detail on each risk, including its drivers, progression across warming scenarios, and specific implications for Māori well-being, governance, and adaptive capacity. These risk profiles inform the case for a structural, rights-based, and tikanga-embedded climate response across Aotearoa.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 1: Risk severity scores under different climate scenarios for all risks in the te ao Māori domain

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Loss of access to taonga species	Localised reductions in access to mahinga kai and taonga species due to land use and ecosystem degradation. Regional variability persists, but tikanga-based practices remain viable in many areas through restoration efforts.	Climate and land-use pressures increasingly restrict access to taonga species across regions, especially marine and freshwater domains. Loss of maramataka cues and taonga species begins to disrupt hauora and intergenerational practice.	Cumulative ecological degradation leads to widespread decline of taonga species across multiple environments. Customary practices and hapū/iwi well-being are severely affected, particularly where regional responses are fragmented or under-resourced.	Collapse of key taonga species populations in some rohe. Cascading effects across Māori economic, ecological, and cultural systems. Without uptake of tikanga-based governance frameworks, loss becomes near-irreversible, undermining identity and mana motuhake.
Māori infrastructure	Many marae, papakāinga, and urupā face heightened exposure to extreme weather such as flooding, erosion, and storms, but some resilience remains where local planning and maintenance systems are in place. Data gaps limit national coordination.	More frequent climate events increase the risk of damage, disconnection, or unsafe conditions. Impacts vary by region and hazard type. Sites with limited funding or repair capacity may experience prolonged disruption.	Repeated exposure to hazards undermines infrastructure viability in multiple regions. Cascading failures may emerge where critical services or Marae are compromised. Lack of investment in Māori-led resilience accelerates decline.	Sustained climate impacts lead to widespread, irreversible damage to Māori infrastructure. Loss of marae, papakāinga, and other cultural assets contributes to systemic disconnection, social fragmentation, and long-term loss of hapū/iwi identity and function.
Economic losses in Māori primary industries	Māori enterprises face systemic barriers in finance and infrastructure. Local climate stress exists, but adaptive capacity improves with support for tikanga-based practices.	Climate extremes disrupt farming, aquaculture, forestry, and fisheries, causing financial stress for values-based enterprises and worsening regional inequities due to infrastructure and ecological issues.	Repeated shocks and ecological disruption undermine Māori economic resilience, making recovery difficult without policy reform. Whānau-scale and tikanga-aligned initiatives face challenges due to increasing climate and regulatory pressures.	Sustained climate stress and underinvestment lead to systemic economic loss, business closures, and long-term vulnerability for Māori economic systems without transformative change.
Disruptions to tikanga and hapū/iwi identity	Mātauranga Māori is being revitalised in some areas but remains marginalised in national climate, research, and planning systems, threatening intergenerational transfer due to ecological degradation and institutional exclusion.	Ongoing environmental disruption, particularly to taonga species, threatens place-based knowledge. Maramataka and seasonal practices may become less viable, especially in areas with insufficient restoration efforts.	As ecosystem shifts accelerate, many communities risk losing lived experience and access to sites of mātauranga. Without coordinated support, knowledge transmission and cultural memory may weaken, particularly in under-resourced areas.	Failing to integrate mātauranga Māori into education and environmental management leads to a loss of knowledge, practices, and intergenerational learning, particularly in areas with altered ecosystems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Loss of indigenous knowledge systems	Mātauranga Māori is actively revitalised in some sectors, but remains marginalised in national climate, research, and planning systems. Ecological degradation and institutional exclusion are beginning to erode the conditions needed for intergenerational transfer.	Ongoing environmental disruption, especially to taonga species and tohu, makes it harder to sustain place-based knowledge. Maramataka and seasonal practices may become less viable in affected regions, particularly where restoration efforts are underfunded or unsupported.	As ecosystem shifts accelerate, many communities may face the erosion of lived experience and loss of access to sites where mātauranga is maintained. Without coordinated structural support, knowledge transmission and cultural memory weaken, especially in under-resourced regions.	Systemic failure to embed mātauranga Māori in education, environmental management, and climate governance leads to widespread knowledge breakdown: practices, place-based memory, and intergenerational learning collapse in areas where ecosystems or access are irreversibly altered.
Legal exclusion and governance	Māori governance models are inconsistently recognised in statutory frameworks. While participation is improving in pockets, legal mandates for Māori leadership remain weak, and exclusion continues to shape planning and decision-making across key sectors.	Climate pressure exposes the consequences of systemic exclusion. Gaps in authority and statutory recognition undermine responsiveness to emergencies, delay local adaptation efforts, and erode trust in public systems among Māori communities.	As the frequency and scale of climate-related events increase, institutional disconnection becomes entrenched. Exclusion from planning and decision-making exacerbates inequality and weakens the legitimacy of adaptation systems, particularly where Māori leadership is marginalised.	Governance systems risk systemic failure where Māori remain excluded. Institutional legitimacy declines, and fragmented authority leads to misaligned or unjust responses. Without structural reform, Māori are left outside formal governance mechanisms just as climate risks intensify.
Increased health vulnerabilities	Māori health vulnerability is increased due to existing chronic conditions, poor housing, and uneven access to culturally safe care. However, strong whānau and marae-based systems provide some buffering capacity in many rohe.	Climate-related health burdens intensify for Māori, particularly in rural and overcrowded housing. Rising temperatures, infectious disease risks, solastalgia, and declining access to marae-based care systems affect well-being. Regional disparities worsen where health reforms lag or infrastructure remains poor.	Māori-led health systems are increasingly strained by repeated climate events, widening mental health impacts and chronic illness disparities. The exclusion of Māori frameworks and data governance undermines effective adaptation and may entrench health system fragmentation.	Compounding stress from frequent disasters leads to system overload, institutional burnout, and intergenerational harm. In the absence of Māori-led planning and sustained investment, health governance may fail to meet Māori needs, with risks becoming systemic and near-irreversible.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.1 Loss of access to taonga species

This section reports on the impacts of climate change on access to taonga species, highlighting the threats it poses to Māori food resilience, tikanga, and the transmission of intergenerational knowledge. Table 2 outlines the risks of losing access to these significant species, emphasising the interplay of environmental degradation, policy gaps, and structural exclusion that collectively undermine access and disrupt the relational frameworks essential for Māori well-being.

While our focus was primarily on aquatic and coastal taonga species, due to their prominence in available impact assessments and community reports, it is crucial to acknowledge that terrestrial taonga species, such as harakeke, rātā, kiwi (*Apteryx* spp.), and other culturally significant flora and fauna, are increasingly endangered by climate change and related biosecurity challenges. Invasive species that are not yet formally recognised as legal biosecurity threats could also harm these taonga species, with potential impacts likely to worsen under anticipated climate scenarios. Therefore, more research is essential to fully understand the cascading cultural and ecological implications for terrestrial ecosystems.

Table 2: Summary table for the risk of loss of access to taonga species

Risk overview	Declining taonga species (e.g. tuna, pāua, kūtai, tuangi, kina, rimurapa and some rongoā) threaten food security, mātauranga, tikanga, and hapū/iwi identity. Loss disrupts intergenerational knowledge, maramataka, and whānau well-being. Restoration efforts exist but require support.
Exposure (current, 2050, 2090)	Māori face increasing exposure to species loss due to rising sea temperatures, ocean acidity, sedimentation, erosion, flooding, and land-use change. Disconnection from mahinga kai affects both tikanga and mātauranga. Exposure is expected to worsen under 1.5°C to 3°C warming, with local variability and data sovereignty gaps compounding the risk.
Sensitivity and adaptive capacity	Sensitivity is high due to dependence on key species. Adaptive capacity exists through Māori-led restoration, wāhine leadership, and Indigenous monitoring; however, efforts are constrained by underfunding, capacity limitations, poor integration into governance, and the persistence of colonial structures.
Compounding and cascading factors	Species loss undermines customary practices, ecological identity, and kaitiakitanga. Cascading effects include erosion of tikanga, reduced youth engagement, diminished hauora, and economic precariousness in aquaculture. Institutional disempowerment exacerbates these risks.
Socioeconomic Trends	The marginalisation of Māori marine and land enterprises, limited climate finance, and extractive economic trends exacerbate access loss. Digital exclusion and policy misalignment prevent Māori from participating fully in mitigation, adaptation, and green finance systems.
Climate thresholds and tipping points	Ecological thresholds for species survival may be crossed in some areas under warming scenarios. Social tipping points include losing maramataka accuracy, mana-enhancing identity, and intergenerational roles. Rebuilding requires long-term, relational recovery beyond technical fixes.
Interactions with mitigation actions	Mitigation efforts can have both positive and negative impacts, and certain types of afforestation and marine development risk disrupting access to taonga. Exclusion from decision making worsens outcomes. Māori governance is essential to ensuring regenerative, not extractive, climate responses.
Data gaps	Limited data on spatial access and harvest viability in some areas. Local government monitoring systems do not recognise mātauranga Māori-informed indicators. Kaupapa Māori-informed surveillance frameworks are promising but underused. Mātauranga-informed indicators need to be included to be mainstreamed.
Confidence level	Evidence is moderate and increasing. There is a strong consensus on severity, but evidence on sensitivity and long-term adaptive capacity is uneven and often local. Theoretical and pilot models exist but are not yet scaled or systematised.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The decline and potential extinction of taonga species, such as mahinga kai species (tuna, kūtai, pāua, tuangi, rimurapa and kina), tipu (plants), and species used for rongoā, pose significant threats not only to food and health resilience but also to the ability to practice tikanga Māori. These species are intricately woven into the spiritual, social, environmental and economic fabric of Māori life. Their loss would sever vital connections to mātauranga Māori, maramataka (seasonal calendars), the intergenerational knowledge systems that uphold hapū/iwi identities and well-being, and accountability to sustainable practices through kaitiakitanga.

Mahuta and van Schravendijk-Goodman (2024) demonstrated how climate change has resulted in the disconnection of some whānau from tuna harvesting in Waikato. This disruption affects essential poukai practices (i.e., gatherings by the Kīngitanga aimed at strengthening the community through hospitality and kōrero), and the associated mātauranga related to kai and ceremony. Similarly, Masters-Awatere, Young, Graham et al. (2022) highlight how the decline of harakeke impedes raranga (weaving), disrupting intergenerational practices and tikanga. Johnson, Fisher & Parsons (2024) further document how environmental degradation impacts hauora/oranga by eroding health-giving relationships with whenua and taonga species, particularly for wāhine Māori. Economic or biomedical frameworks do not easily capture this experiential loss of relational well-being and represent a profound emotional impact (Johnson, Fisher & Parsons 2024). Erueti et al. (2023) reinforced the view that taonga species are deeply interwoven with Māori ontologies (ideas of being), with their decline compromising the relational and place-based ethics that inform tikanga and biosecurity practice.

Climate change also intensifies pressures on significant mahinga kai species (many of which are coastal/marine), leading to dire consequences for kaitiakitanga, tribal economies, and eroding whānau connections to their kāinga and therefore well-being. For example, pāua are increasingly affected by warming seas, sedimentation, and acidification, which undermine recruitment, habitat, and survival rates (Short et al. 2023). Sediment from land-use change (e.g. forestry, farming) and run-off degrade estuarine and marine habitats, smothering shellfish beds, affecting the abundance and distribution of mahinga kai species like pipi, tuangi, pāua, and kina (Morrison et al. 2023). Exposure to environmental contamination, such as heavy metals and to both point and diffuse discharges, poses direct risks to mahinga kai (Mayall-Nahi et al. 2021). Current metrics do not reflect Indigenous standards for marine food safety (Kainamu-Murchie et al. 2018). Climate change further exacerbates the risks, including those of contaminant bioavailability and to population resilience under acidification (Lohrer et al. 2024). This is especially concerning given that mahinga kai species, including tuangi and kina, have been found to be vectors of harmful bacteria (Rouchon & Phillips 2017; Kainamu-Murchie et al. 2018; van Hamelsveld et al, 2023).

In the northern regions of Aotearoa, anthropogenic pressures, such as overfishing, have resulted in the removal of taonga species that act as natural predators (such as tāmure and kōura), causing a trophic cascade. For example, the significant removal of these predators has led to increased kina populations, and kina overgrazing has diminished the presence of kelp, resulting in areas known as "kina barrens" (Lundquist et al. 2011; Bulmer et al. 2024). Warming seas and declining biodiversity intensify these pressures (Bulmer et al. 2024) and disrupt harvesting and other practices, which in turn have effects on intergenerational knowledge transfer and hapū food sovereignty (Hayden et al. 2023; Kainamu & Rolleston-Gabel 2023).

Rising ocean temperatures and the accumulation of microplastics also threaten mussel spat supplies, jeopardising customary harvest practices and aquaculture operations (Paul-Burke et al. 2022). As highlighted in Johnson et al. (2022), these changes are not experienced uniformly; subjectivities such as gender, class, and age affect how Māori individuals and households experience vulnerability and adapt to such biophysical losses, which can complicate equitable adaptation planning. These ecological changes are biological and knowledge-based, threatening

© New Zealand Institute for Bioeconomy Science Limited (2026)

Indigenous languages, dialects, and species-naming systems, as seen in localised dialect erosion linked to species disappearance (Aitken et al. 2021).

Wāhine Māori in Te Tai Tokerau (Northland) have expressed concern that degraded access to taonga species, such as kūtai and tuna, diminishes their ability to enact their roles as kaitiaki (guardians/stewards) and disrupts tikanga-based mentoring practices (Johnson et al. 2022; Johnson, Fisher & Parsons 2024). This includes losing opportunities to guide urban rangatahi through place-based learning and seasonal harvesting practices, particularly at significant dune lakes and river systems. For example, one narrative in Johnson, Fisher & Parsons (2024) describes how declining water quality and species abundance have impeded this person's use of hīkoi-based learning and environmental rituals, in turn undermining efforts to strengthen youth identity and connection to whenua. These experiences highlight the non-economic dimensions of loss and damage and the importance of mana enhancing as a strategy for adaptation and healing.

Te Rūnanga o Te Rarawa (2021) further observed that climate change exacerbates existing disconnection from species and landscapes central to collective identity. Declines in the mauri of dune lakes and forested catchments are seen as ecological and relational losses by Māori, with practical impacts on customary education, ritual observance, and whānau well-being. This observation aligns with the findings of Cram (2021), who documented how tikanga, including gathering, preparing, and sharing kaimoana, acts as an expression of manaakitanga and sustains intergenerational well-being.

These findings suggest that losing taonga species triggers cascading effects across tikanga, affecting ceremonial observance, intergenerational knowledge transmission, and the ability to maintain ahi kā and enact kaitiakitanga. While restoration efforts (e.g., spat-catching, kelp regeneration) provide promising pathways for adaptation, as noted in Paul-Burke et al. (2022), the ability to scale these initiatives depends on sustained funding, Indigenous-led monitoring, and the institutional recognition of tikanga in biodiversity management (Sharma et al. 2024; Wood et al. 2024).

3.1.1 Exposure – current, 2050 and 2090:

Māori communities are experiencing increasing exposure to the decline of several taonga species. This exposure arises from a combination of environmental stressors, including rising sea temperatures, sedimentation, and storm impacts, which are linked to climate change and land-use pressures (Short et al. 2023; Bulmer et al. 2024; Mahuta & van Schravendijk-Goodman 2024).

In some regions, particularly coastal and lowland areas, customary harvesting practices are already being affected. For example, disconnection from tuna harvesting in Waikato has been linked to disruptions in poukai and associated practices (Mahuta & van Schravendijk-Goodman 2024). The degradation of mahinga kai environments in areas like Hawke's Bay, exacerbated by forestry run-off and sedimentation following extreme weather events, has also contributed to reduced availability of shellfish and fish species (Envirostrat Limited 2024). While not universal, these patterns are becoming more common and are cited as a concern for intergenerational knowledge transmission and well-being (Masters-Awatere, Young, Graham 2022). These patterns align with mapped environmental stress networks, demonstrating cascading risks to Indigenous values from environmental degradation (Yletyinen et al. 2022).

Wāhine Māori in Te Tai Tokerau have described increased exposure to degraded dune lakes and river systems that once served as intergenerational teaching spaces for customary harvest and ritual (Johnson, Fisher & Parsons 2024). Declines in water quality and tuna abundance have

© New Zealand Institute for Bioeconomy Science Limited (2026)

reduced the frequency and quality of hīkoi, reducing opportunities for knowledge transmission and healing.

By mid-century, under a global warming level (GWL) of approximately 1.5°C to 2°C, exposure is expected to increase further in Te Tai Tokerau. Projected impacts of warming include continued stress on marine and freshwater species due to temperature shifts, biosecurity threats, and changes in ocean chemistry (Short et al. 2023). Local conditions and mitigation responses will determine whether some populations remain viable. Mannakkara et al. (2023) highlighted how climate impacts on taonga species will be spatially variable but increasingly widespread under mid-century projections in Te Tai Tokerau. They noted that failure to integrate mātauranga Māori into local government adaptation processes increases place-based exposure and erodes response capacity. A study by Sharma et al. (2024) on geospatial data sovereignty notes that if maps and location data about climate threats are made or used without Indigenous consent and control, it can make communities more vulnerable, because it breaks their connection to local, place-based ways of adapting.

By the end of the century (i.e. in approximately 2090), with global warming levels (GWLs) of 2°C to 3°C or higher, the loss of access to these species may become more widespread in vulnerable ecosystems. However, the extent of this risk will be shaped by future ecological conditions, management responses, and Māori-led adaptation strategies. Initiatives with mussel species, such as developing taura kuku and kohunga kūtai, show how innovation grounded in mātauranga Māori can support resilience, although these efforts currently operate with limited support (Paul-Burke et al. 2022; Skelton et al., 2023). Lambert and Mark-Shadbolt (2021) argued that where watchfulness and kaitiakitanga are well supported, exposure to pathogens may be mitigated by early detection and community mobilisation.

The spatial and ecological modelling of species-specific climate effects is moderately uncertain due to limited data on taonga species and places (especially non-commercial species, and estuarine and marine environments). A Climate Change Vulnerability Assessment (CCVA) has been done for eight freshwater taonga species (Egan et al. 2020); and tuangi are one of the marine taonga species currently in assessment (a draft paper by Kainamu et al. on this is currently in preparation). The CCVA is recommended as the first step towards increasing our understanding of the potential effects of climate change on taonga species in Aotearoa (Egan et al. 2020). Additionally, taonga species exposure is difficult to quantify, given the diversity of iwi and hapū relationships with taonga species. Nevertheless, the evidence indicates that Māori exposure to this risk is growing and requires close monitoring and a tikanga-based response.

3.1.2 Sensitivity and adaptive capacity

Māori communities are susceptible to the decline or loss of taonga species such as tuna, pāua, kūtai, kina, and rongoā species. These species are important sources of kai and medicines and deeply embedded in hapū/iwi identity, intergenerational knowledge transmission, and customary practices. The sensitivity arises from the central role that these species play in enacting tikanga, maintaining whanaungatanga, and expressing kaitiakitanga within specific ecosystems and seasonal cycles (Te Rūnanga o Te Rarawa, 2021; Johnson et al. 2022; Mahuta & van Schravendijk-Goodman 2024). As Ayala (2023) noted, Māori ethics centre relationships among people, place, and other beings. When biosecurity crises cut those strands, the kete frays, harm layers across personal, whānau, ecological, economic and intergenerational levels.

The significance of these taonga species extends beyond their material uses. Their decline can disrupt poukai traditions, maramataka-based harvesting, and ceremonial practices. The erosion of these practices risks weakening mana whenua relationships with place and diminishing

© New Zealand Institute for Bioeconomy Science Limited (2026)

mātauranga Māori, notably when opportunities for hands-on transmission are reduced (Paul-Burke et al. 2022; Skelton et al. 2023). Gender, caregiving roles, and place-based responsibilities further differentiate this sensitivity. For instance, wāhine Māori express concern that the loss of sites for kūtai and tuna harvesting undermines their roles as educators and intergenerational mentors, especially for disconnected rangatahi (Johnson et al. 2022; Johnson, Fisher & Parsons 2024).

In this sense, Māori sensitivity is rooted not only in dependence on the species themselves but also in the systemic and historical context that has limited their ability to control environmental outcomes. This includes colonisation, resource alienation, and exclusion from resource management regimes (Hikuroa et al. 2021; Macpherson et al. 2023). Tapsell (2022) documented how colonial governance structures that devalue tikanga-based authority amplify this vulnerability, especially where disconnection from taonga is driven by environmental degradation. A Te Rarawa Cultural Impact Assessment (Te Rūnanga o Te Rarawa 2021) similarly showed how cumulative impacts from wastewater, drainage, and water extraction in the Awanui catchment have eroded the mauri of wetland systems, undermining tikanga.

Māori adaptive capacity in this domain is strong but constrained. Several iwi, hapū, and whānau are actively engaging in restoration and innovation initiatives grounded in mātauranga Māori. Examples include biodegradable spat-catching lines (taura kuku) for mussel restoration (Paul-Burke et al. 2022), kelp forest recovery in kina-affected ecosystems (Bulmer et al. 2024), and the application of Māori indicator-based monitoring frameworks to assess environmental change (Mannakkara et al. 2023; Wilcox et al. 2024). Bissett (2025) showcased the role of Indigenous-led seed banking and restoration practices in enhancing adaptive capacity, particularly where seed sovereignty and local propagation are tied to cultural revitalisation. Wāhine-led environmental leadership is also a key feature of these responses, linking health/well-being (oranga) to the regeneration of species and places (Johnson, Fisher & Parsons 2024; Mannakkara et al. 2023).

These initiatives reflect deep knowledge and localised response capacity. However, many operate with limited funding, institutional support, or integration into national adaptation systems. This under-resourcing restricts their ability to scale and sustain long-term outcomes (Envirostrat Limited 2024; Skelton et al. 2023). Hikuroa et al. (2021) argue that Māori-led market innovations, such as values-based freshwater allocation, are often constrained by regulatory misalignment with mana whenua-based governance. These structural limitations reduce the ability of iwi and hapū to implement tikanga-based adaptation. Bargh & Tapsell (2021) stress that Māori adaptive capacity will remain structurally limited without constitutional reform and co-governance.

Uncertainty in climate-risk assessment for taonga species stems primarily from gaps in ecological data specific to taonga species and limited formal recognition of Mātauranga-informed metrics in environmental assessment. While some case studies are well documented, there is variability across rohe regarding monitoring capacity and data availability (Morgan et al. 2021). Furthermore, the cumulative impacts of warming seas, pollution, and ocean acidification on taonga species are complex and unpredictable at local scales. As a result, there are data gaps throughout the country. Wood et al. (2024) showed that the Mātauranga Māori Framework for Surveillance (MMFS) can reduce uncertainty through integrated Indigenous-led monitoring. Long-term practice, continuity, and consistent tikanga-based methodologies are key to how that framework enhances certainty and ecological responsiveness.

3.1.3 Compounding and cascading factors

The loss of access to taonga species is a consequence of other climate-related risks and a driver of further social and economic vulnerability. Environmental degradation caused by marine heatwaves, sedimentation, and biodiversity decline, often exacerbated by upstream land-use

changes, forestry practices, and extreme weather events, directly contributes to species decline (Te Rūnanga o Te Rarawa 2021; Johnson, Fisher & Parsons 2024; Skelton et al. 2023; Bulmer et al. 2024). For example, sedimentation and forestry slash following extreme weather events, as observed after Cyclone Gabrielle, have impacted mahinga kai ecosystems in Hawke's Bay, affecting species such as pāua, kina, and kūtai (Short et al. 2023; Envirostrat Limited 2024). These environmental stressors compound exposure for Māori inland and coastal communities whose food resilience and tikanga are closely tied to the availability and condition of marine taonga species and the health of ecosystems (Egan et al. 2020; Mayall-Nahi et al. 2021; Johnson et al. 2022; Short et al. 2023; Bulmer et al. 2024). Ayala (2023) documents Hikoi-based research shows that when access to forests and species is limited, it harms the deep connections Māori people have with their environment, affecting both their understanding of nature and the way they pass on their knowledge. This loss of sensory, narrative, and embodied experience contributes to the erosion of ecological identity and the sustained practice of tikanga.

Biosecurity risks compound these pressures. The incursion of pathogens such as those causing myrtle rust and kauri dieback has damaged culturally significant forests and disrupted access to forests vital to both customary and commercial uses (Lambert & Mark-Shadbolt 2021). These disruptions not only reduce biodiversity but also contribute to a cascading loss of species central to tikanga, mātauranga, and hapū identity. Such risks overlap with climate pressures and create cumulative effects on taonga species. In turn, these undermine whānau capacity to engage in kaitiakitanga and economic recovery.

At the same time, the loss of keystone/taonga species may drive cascading impacts across multiple domains. Declines in taonga species weaken the practice of maramataka-based harvesting, disrupt customary gatherings and rituals, and erode the transmission of place-based environmental knowledge (Paul-Burke et al. 2022; Kainamu & Rolleston-Gabel 2023; Mannakkara et al. 2023; Skelton et al. 2023). This risk contributes to the broader erosion of mātauranga Māori and can heighten identity loss, particularly where environmental decline interrupts customary practice and intergenerational knowledge transmission (Masters-Awatere, Young, Graham 2022). Johnson, Fisher & Parsons (2024) noted that the disappearance of accessible harvest sites impairs the ability of wāhine Māori to lead environmental rituals and tikanga-based mentoring for urban rangatahi. As these roles are disrupted, opportunities to reinforce identity, language, and relational belonging through environmental practice are diminished. The decline of tikanga affects both knowledge and emotions. As shown in Apiti et al. (2023), a strong connection to the environment, which is related to but separate from Māori identity, is the main factor linked to environmental distress among Māori. This suggests that ecological decline causes significant emotional and psychological problems.

For rangatahi Māori, the absence of opportunities to engage in customary harvesting of taonga species, or in education about taonga species, can contribute to disconnection from whenua and collective identity (Johnson, Fisher & Parsons 2024; Ratana 2023). Tapsell (2022) stressed that the breakdown of tikanga relationships, through the erosion of care, reciprocity, and recognition in governance, may cause systemic harm to social cohesion and environmental guardianship. Mannakkara et al. (2023) noted that in regions like Te Tai Tokerau, the loss of species is frequently described by Māori participants as a breakdown in reciprocal responsibilities, where the ability to uphold kaitiakitanga becomes impossible due to structural and ecological pressures. This undermines kaitiakitanga and identity, particularly in hapū with limited access to freshwater or coastal decision-making forums. Economic risks may also be amplified when aquaculture operations based on vulnerable species become non-viable due to compounding ecosystem stressors, reducing whānau income and enterprise resilience (Howarth & Major 2023; Mika & MacDonald 2024). Therefore, the disruption of keystone/taonga species access is symptomatic of broader climate pressures and a driver of social and economic instability.

© New Zealand Institute for Bioeconomy Science Limited (2026)

These cascading impacts can feed back into institutional settings. As Lambert and Mark-Shadbolt (2021) observed, failure to invest in iwi- and hapū-led forest and biodiversity management results in lost ecological resilience and missed opportunities to re-centre Māori governance in climate adaptation. When compounded by climate disruption, the disempowerment of Māori in environmental decision making has the effect of limiting the opportunities for institutional learning (by environmental decision making organisations) that is necessary for equitable adaptation to occur. Hikuroa et al. (2021) stressed that without realigning regulatory and market systems to uphold whakapapa and mana whakahaere, the cascading consequences for hapū and iwi well-being will persist. In this context, the erosion of taonga species reflects a broader governance misfit that undermines both Aotearoa's biodiversity commitments and Indigenous sovereignty.

3.1.4 Socioeconomic trend(s) that may exacerbate the risk

A key socioeconomic trend that may exacerbate the risk of Māori losing access to taonga species is the increasing marginalisation of Māori marine and land-based enterprises within mainstream environmental and economic systems. Māori aquaculture and customary fisheries, often small-scale and values-based, face rising barriers in accessing climate finance, regulatory support, and infrastructure investment (Envirostrat Limited 2024; Mika & MacDonald 2024). At the same time, ecosystem degradation driven by sedimentation, marine heatwaves, and land-use change is reducing the availability of taonga species such as pāua, kūtai, and tuna (Te Rūnanga o Te Rarawa 2021; Morrison et al. 2023; Short et al. 2023; Bulmer et al. 2024; Lohrer et al. 2024). These constraints are closely tied to longstanding governance barriers. Bargh and Tapsell (2021) argue that realising a "tika transition" requires constitutional recognition of the rangatiratanga sphere as a legitimate political and governance domain within environmental decision making.

Despite growing recognition of Te Mana o te Wai (a concept referring to the fundamental importance of water and its health, recognised by the Ministry for the Environment in its policy documents and statements), many Māori-led initiatives remain on the periphery of climate policy and adaptation funding. This marginalisation limits the capacity of iwi, hapū, and whānau to exercise mana whakahaere or invest in long-term, tikanga-based restoration of taonga species. As seen in Greater Wellington's Te Whaitua te Whanganui-a-Tara Implementation Programme, while the programme establishes a bicultural governance model and champions community-led action, it also acknowledges that structural barriers, such as fragmented funding systems, underinvestment in Māori infrastructure, and slow institutional uptake of Māori planning frameworks, continue to hinder implementation (Whaitua Te Whanganui-a-Tara Committee 2021). The limited integration of Māori knowledge systems, rights, and relational ethics into resource management frameworks compounds this trend, weakening the capacity to maintain or restore species in tikanga-based ways (Hikuroa et al, 2021; Paul-Burke et al. 2022; Skelton et al. 2023).

This disconnect was reflected in Johnson et al. (2022), where wāhine Māori in Te Tai Tokerau noted that the loss of access to real-time environmental data, local species knowledge, and safe harvesting spaces reduces their ability to mentor rangatahi in maramataka and tikanga-based harvesting. Sharma et al.'s (2024) case study on Māori biodiversity data sovereignty demonstrated how digital infrastructure gaps and the absence of secure, Indigenous-controlled systems prevent many Māori environmental groups from participating in modern geospatial or cloud-based data environments, leaving them unable to access or verify the data sets used to manage taonga species.

In addition to enterprise-level barriers, there are socioeconomic trends that limit individual and whānau access to taonga species, particularly mahinga kai ones. These include inequities in transport infrastructure, cost, and service availability, which reduce access to remote customary

© New Zealand Institute for Bioeconomy Science Limited (2026)

harvest sites. As noted by Sweeney et al. (2022), Māori aspirations for land transport have historically been poorly integrated into planning frameworks, leaving some rural or urban-dispersed whānau unable to reach mahinga kai. Housing insecurity and precarious employment diminish the stability and capacity required for customary harvesting, collective food preparation, and seasonal access to taonga species. These compounding structural conditions intensify vulnerability, particularly for rangatahi, low-income whānau, and urban-based households (Cram 2021; Paul & Ratana 2022).

Broader economic pressures, such as the centralisation of aquaculture, the commodification of carbon credits through afforestation, or extractive marine development, may further entrench inequities. The AUT 'Living Laboratories Program' (Buckley et al. 2023) has highlighted how farm-based ecological restoration projects co-led by iwi are often undervalued compared to monocultural planting schemes prioritised for their quick carbon sequestration returns. These market preferences can divert investment away from native species restoration or tikanga-based systems of land care. In addition, Johnson et al. (2022) noted that exclusion from green finance and regulatory regimes can disproportionately affect wāhine Māori and low-income households, whose customary use of taonga species is not easily monetised or validated by mainstream economic systems.

As these pressures converge, whānau and hapū may find it increasingly challenging to sustain customary harvesting practices, placing sustained practice of tikanga and food resilience at greater risk. This risk was also emphasised in King-Hunt's (2023) Master's thesis and by Palmer et al.'s (2020) work, where some participants linked unfamiliar or externally imposed science-based interventions to more profound anxieties about marginalisation, consent, and the erosion of tino rangatiratanga. These concerns align with a broader consensus in the literature. Without structural resourcing and political recognition, Māori-led responses to taonga species decline will risk becoming isolated or symbolic rather than systemic.

3.1.5 Climate thresholds and tipping points

Several ecological and socio-economic thresholds may influence the severity of the risk associated with the loss of taonga species. Biophysical thresholds include temperature and acidification limits beyond which the reproduction, growth, or survival of key taonga species such as pāua, kūtai, and kina may significantly decline. For example, marine heatwaves and sedimentation from upstream land use may reduce habitat quality and larval recruitment beyond the capacity of aquaculture systems or natural regeneration to recover (Howarth & Major 2023; Short et al. 2023; Skelton et al.,2023; Bulmer et al. 2024). If such thresholds are crossed, particularly under high-emissions scenarios i.e. (2.5°C to 3.5°C warming), taonga species may experience regional or irreversible declines. Adaptive responses, such as Māori-led restoration projects and the development of biodegradable spat lines (taura kuku), could be exceeded if warming trends accelerate or if ecosystem degradation continues to outpace recovery efforts (Paul-Burke et al. 2022; Skelton et al. 2023).

These biophysical tipping points also overlap with social thresholds. As Yletyinen et al. (2022) explained through network analysis with Ngāti Wai, deeply connected value systems can cascade when even a single keystone species becomes inaccessible, triggering declines in multiple interrelated values such as manaakitanga, whakapapa, and environmental responsibility. A tipping point may be reached when the loss of taonga species results in the widespread breakdown of customary practices, intergenerational transmission of mātauranga Māori, and food resilience systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Extreme weather events, particularly floods, have already crossed ecological and social thresholds for Māori communities, severely affecting taonga species and triggering socio-ecological tipping points. Cyclone Gabrielle (in 2023) provided a striking example: the event generated large-scale sedimentation and forestry slash across Hawke's Bay, smothering mahinga kai ecosystems and degrading habitats for culturally significant species such as pāua, kina, and kūtai (Short et al. 2023; Envirostrat Limited 2024). This habitat loss disrupted both customary harvesting and restoration trajectories, as warming seas and sedimentation reduced larval recruitment and habitat quality beyond the capacity of either aquaculture systems or natural regeneration to recover (Skelton et al. 2023; Bulmer et al. 2024). People's disconnection from taonga species has also initiated social tipping points. For example, the decline of tuna populations in Waikato has impaired poukai gatherings and the associated transmission of maramataka- and food-related tikanga, while wāhine Māori in Te Tai Tokerau have reported that loss of access to kūtai and tuna undermines their ability to mentor rangatahi through tikanga-based hīkoi and harvesting practices (Johnson, Fisher & Parsons 2024; Mahuta & van Schravendijk-Goodman 2024). These cascading impacts erode intergenerational well-being, environmental identity, and the relational frameworks that sustain kaitiakitanga and community resilience under climate stress (Yletyinen et al. 2022; Apiti et al. 2023).

For example, the sustained population collapse of tuna or pāua could undermine the viability of poukai, maramataka-based harvesting, and whānau-based governance practices that rely on taonga species (Masters-Awatere, Young, Howard, et al. 2022; Mahuta & van Schravendijk-Goodman 2024). This was reflected in work by Apiti et al. (2023), who found that Māori participants experienced heightened environmental distress when environmental decline disrupted their ability to act on environmental identity, particularly through engaging in kaitiakitanga, harvesting, or place-based learning with mokopuna. Johnson, Fisher & Parsons (2024) provided further evidence that when wāhine Māori cannot access clean rivers or gather kai with mokopuna (grand-children/descendants), it compromises their ability to transmit values like manaakitanga and kaitiakitanga. Such a loss weakens the confidence of rangatahi to step into future leadership and participate in care for their environment.

Once disrupted, returning to these tikanga may be difficult or impossible without a sustained, multi-generational recovery process. This risk is compounded by institutional constraints, such as the absence of marine governance settings that integrate Indigenous knowledge and long-term ecosystem baselines (Macpherson et al. 2023). The Mātauranga Māori Framework for Surveillance of Plant Pathogens (Wood et al. 2024) offers a partial safeguard against tipping points by embedding Indigenous monitoring into biosecurity and pathogen control. However, the sustainability of such frameworks is at risk when support is ad hoc or not enshrined within statutory decision making. As ocean warming and ocean acidification progress, these socio-ecological tipping points become increasingly plausible under high-emission scenarios. Tapsell (2022) warned that once the ethic of care embedded in tikanga and environmental relationships is disrupted by settler institutions or degraded ecosystems, restoration must begin with species and relationships; and this will require constitutional and relational governance transformation, not just technical fixes. The severity of this risk lies not just in the environmental thresholds crossed, but in the collapse of the collective and relational frameworks that sustain Māori well-being.

3.1.6 Possible interactions with climate mitigation actions

Some climate mitigation actions, particularly those related to land-use change, marine spatial planning, and emissions reduction in agriculture and aquaculture, may interact with the risk of Māori losing access to taonga species. On the one hand, effective mitigation, particularly at the global level, could reduce the magnitude of warming and slow the degradation of marine

ecosystems, thereby decreasing the likelihood of keystone species collapse (Howarth & Major 2023; Skelton et al. 2023). However, local mitigation efforts, such as expanded afforestation or carbon farming on marginal coastal or riparian land, can inadvertently reduce Māori access to traditional harvesting sites or alter hydrological conditions affecting mahinga kai (Ministerial Inquiry into Land Use 2023). In the Awanui catchment, for example, the Te Rarawa cultural impact assessment (Te Rūnanga o Te Rarawa 2021) raised concerns that mitigation schemes focused on exotic forestry and flood protection have excluded mātauranga Māori values, resulting in changes to water regimes that diminish tuna habitat and block traditional access paths.

Tapsell (2022) argued that without attention to whakapapa relationships and mana whenua governance, land-use decisions made in the name of climate mitigation may reinforce colonial patterns of dispossession under the guise of sustainability. This view is especially relevant in contexts where Indigenous decision making is excluded from the design of mitigation schemes; or where monocultural approaches, such as exotic carbon forestry, supersede iwi-led ecological restoration priorities that champion mixed land-use strategies (Pohatu et al. 2020).

Marine-based climate change mitigation efforts, such as offshore renewable energy developments or ocean carbon sequestration, could introduce new spatial conflicts if they overlap with customary marine areas or the habitats of taonga species. While not a primary focus of Bargh and Tapsell (2021), their work supports the view that managed retreat and marine infrastructure must be Te Tiriti-consistent, and that the current legislative landscape lacks strong provisions for Māori-led climate decision-making. Without co-governance, climate mitigation projects risk displacing – or marginalising – hapū and iwi interests in coastal ecosystems already under pressure.

Climate change itself may also make some mitigation actions harder to achieve. For example, as sea temperatures rise and shellfish mortality increases, the resilience and productivity of low-emission Māori aquaculture systems may decline, making it more difficult for Māori aquaculture projects to meet emissions efficiency or sustainability certification standards (Mika & MacDonald 2024). Sharma et al. (2024) noted that climate-aligned Māori aquaculture projects face additional risks when digital infrastructure, privacy, and Indigenous data sovereignty are not integrated into cloud-based management tools, potentially excluding Māori enterprises from emerging green finance systems.

All these factors could undermine access to carbon markets or climate-aligned finance, particularly for small-scale whānau enterprises. Conversely, the loss of keystone species may increase demand for restorative seaweed aquaculture or kelp forest regeneration as a form of blue carbon mitigation, with potential co-benefits for human health and ecosystem recovery if Māori governance is central to project design (Tai-o-Rongo Research Collective 2024). However, such benefits depend on enabling legal, funding, and planning frameworks. The direction and scale of these interactions depend on how mitigation actions are framed: whether extractive or regenerative, centralised or Māori-led; and whether they are designed by those with the mana whenua to do so.

3.1.7 Data gaps

There are significant evidence gaps for this risk, particularly around spatially specific exposure and sensitivity metrics. While some research exists on the ecological impacts of warming seas, sedimentation, and species decline (e.g. of pāua, kūtai, tuna), there is limited disaggregated data on the extent of climate impacts to mahinga kai as well as how these changes are affecting Māori access to mahinga kai and customary harvesting across rohe (Te Rūnanga o Te Rarawa 2021; Short et al. 2023; Skelton et al. 2023). Monitoring systems often focus on biophysical conditions (e.g. shellfish abundance) but do not incorporate Māori-defined thresholds, such as the viability of mahinga kai practices or impacts on tikanga and maramataka-based practices.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The adaptive capacity of Māori-led aquaculture, restoration, or fisheries innovation is also under-documented, particularly in terms of its long-term sustainability under climate stress and institutional barriers to scaling (Paul-Burke et al. 2022; Mannakkara et al. 2023; Mika & MacDonald 2024). Aitken et al. (2021) highlighted how local dialectal names for flora and fauna are disappearing as species decline. However, this hapū/iwi priority is rarely tracked in conservation frameworks. The social and psychological effects of disconnection on rangatahi Māori, especially regarding identity and language, are also supported qualitatively by Apiti et al. (2023) but have not been captured in national-scale metrics or models.

Mātauranga Māori indicators are often excluded from formal ecosystem condition reporting, meaning that early warnings from Māori of changes in ecological and hapū/iwi well-being may be missed or underweighted. Lambert and Mark-Shadbolt (2021) caution that Māori-led biodiversity monitoring risks becoming structurally invisible if tikanga are not built into reporting frameworks or data governance rules. Johnson, Fisher & Parsons (2024) demonstrated that tikanga-based mentoring efforts, especially those led by wāhine Māori, are often site-specific, episodic, and therefore under-represented in cumulative monitoring frameworks. Without place-based mātauranga-informed indicators, shifts in harvest confidence, ritual activity, or intergenerational access may go undocumented until the practice breakdown is already advanced. Salmond et al. (2023) argued that unless Māori world views are encoded into the success metrics of restoration and mitigation programmes, the conventional indicators may signal ecological recovery while masking declines in tikanga. This includes failing to account for reduced mana whenua participation, seasonal timing mismatches, or species loss critical to identity and ceremony.

This invisibility is not just a measurement issue; it directly undermines the legitimacy of Māori-led adaptation and risk disclosure.

3.1.8 Confidence level

The available evidence for the risk of loss of access to taonga species is moderate in quality and increasing in quantity, with strong thematic agreement across sources. Studies from the Sustainable Seas Challenge (one of the NSC challenges) and applied research in aquaculture and mahinga kai restoration offer a reasonably robust evidence base for biophysical exposure, particularly about warming seas, sedimentation, and species-specific vulnerabilities (e.g., of pāua, kūtai, tuna) (Short et al. 2023; Skelton et al. 2023; Bulmer et al. 2024).

Across the documents reviewed, there is consistent agreement that climate-driven ecological changes and cumulative land-use pressures increasingly constrain Māori access to these species. However, sensitivity and adaptive capacity evidence was less consistent, often relying on regional case studies or project-specific evaluations (e.g., Te Rūnanga o Te Rarawa 2021; Johnson, Fisher & Parsons 2024). For instance, while initiatives such as biodegradable spat lines and kelp forest restoration show promise, their long-term resilience under warming scenarios remains poorly understood at a large scale (Paul-Burke et al. 2022; Skelton et al, 2023).

Tapsell (2022) and Bargh & Tapsell (2021) provided a strong theoretical framework for risk's relational and governance dimensions. However, the operationalisation of their proposals remains incomplete, resulting in uneven policy impact. Similarly, Sharma et al. (2024) identified promising pathways for Māori digital sovereignty and data integration. However, these remain at the proposal or pilot stage and have not yet been embedded in official systems. Johnson et al. (2022) reinforced the view that relational, emotional, and intergenerational impacts, particularly for wāhine Māori and rangatahi, are under-documented in risk assessments, and that confidence in capturing these dimensions remains low. Mannakkara et al. (2023) confirmed that Indigenous priorities are often

© New Zealand Institute for Bioeconomy Science Limited (2026)

weakly integrated in local mitigation and adaptation planning, reducing confidence that institutional responses are currently addressing the full scope of exposure and resilience.

Despite these caveats, there was a strong consensus that this is a high-severity and under-recognised risk, particularly in terms of sustained practice of tikanga and intergenerational knowledge. The Mātauranga Māori Framework for Plant Pathogen Surveillance (Wood et al. 2024), AUT's 'Living Laboratories' project (Buckley et al. 2023), and Sharma et al.'s (2024) geospatial governance model offer emerging evidence-informed solutions. However, broader institutional uptake is required to elevate confidence levels across all dimensions of risk.

3.1.9 Risk severity summary

Table 3 presents the risk severity criteria for loss of access to taonga species across four levels of risk, from minor to extreme, drawing on published literature to assess how biodiversity decline, ecological disruption, and policy misalignment may impact Māori relationships with taonga species over time. The risk severity criteria were used to inform the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 3: Loss of access to taonga species risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Localised disruptions to specific harvest sites or species. • Impacts mostly recoverable through existing restoration or monitoring. • Little to no effect on tikanga or intergenerational practices at the system scale.	• Regionalised taonga loss affects customary practices and intergenerational knowledge. • Some slow-onset impacts on identity and well-being. • Restoration efforts underway but fragmented.	• Widespread loss of key species disrupts maramataka, hauora, and mātauranga. • Cultural identity and tikanga under significant stress. • Customary practice breakdown likely in multiple rohe.	• Collapse of taonga species across rohe triggers social, cultural, and ecological tipping points. • Tikanga and intergenerational knowledge transmission destabilised. • Loss becomes near-irreversible without systemic transformation.
Extent, Duration & Frequency	• Localised or seasonal declines in species abundance. • Practices temporarily suspended but able to resume.	• Multiple species under pressure across rohe. • Cyclical or prolonged disruptions to harvest and mentoring. • Impacts visible in hapū education, health, and social cohesion.	• Persistent loss of access to keystone species across coastal, freshwater, and forest domains. • Social and cultural roles severely eroded (e.g., provision of kai at hui).	• Intergenerational disconnect from mahinga kai, spiritual markers, and ecosystems. • Decline of key species leads to breakdown of te reo and tikanga.
Ability to Recover	• Local-scale mitigation or restoration projects restore function. • Tikanga resumes after short disruption.	• Partial recovery dependent on restoration projects. • Institutional support inconsistent. • Reputational damage or loss of trust in environmental systems noted.	• Full recovery requires structural policy shifts and investment in Māori-led solutions. • Tikanga relationships need rebuilding. • Institutional disempowerment evident.	• Recovery unlikely without tikanga and mana whakahaere • System legitimacy eroded. • Cultural revitalisation effort becomes generational.
Likely Equity Impacts	• Minimal inequities generated. • Access to species and harvest practices remains inclusive.	• Exclusion of Māori from environmental data and planning hinders adaptation. • Regional inequities emerging.	• Māori disproportionately bear losses due to land-use change, mitigation trade-offs, and underinvestment. • Customary economies, especially wāhine-led, impacted.	• Systemic exclusion entrenched. • Māori voices sidelined in biodiversity and adaptation governance. • Cultural dislocation intensifies.
Likely Impacts on Te Ao Māori	• Planning systems overlook mātauranga but do not actively exclude it. • Māori-led restoration under-supported.	• Tikanga considered inconsistently; metrics for taonga recovery remain Western-framed. • Maramataka or kaitiakitanga only partially recognised.	• Taonga loss leads to diminished wellbeing, ritual participation, and intergenerational transfer. • Whānau-based governance compromised.	• Māori infrastructure, pūrakau, and customary ceremonies collapse. • Tikanga is marginalised • Māori-led governance no longer viable under dominant adaptation systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 4 below) elaborates on the projected severity of damage to the loss of access to taonga species under different warming scenarios, drawing on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. We utilised the Commissions' scoring template for compiling our risk severity scores (see Appendix 3). By mid-century (1.5°C–2°C warming), more regions will likely experience reduced access to taonga species. By the end of the century (2.5°C–3.5°C warming), the cumulative impacts of climate and land-use pressures may cause the collapse of taonga species in some areas, leading to a decline in environmental and hapū/iwi well-being. This projection aligns with ecological modelling cited in Short et al. (2023) and Skelton et al. (2023). However, based on the evidence, our confidence in species-specific collapse remains moderate due to both persistent data gaps and significant regional variation in projected climate patterns, such as warmer, wetter conditions in some areas and increased drought risk in others. These different paths may lead to various impacts on taonga species that are not straightforward and can vary in different areas. Yletyinen et al. (2022) showed that ecological values are tightly interlinked with hapū/iwi identity, and their degradation or collapse, whether through abrupt loss or slow transformation, may cascade throughout Māori economic, social, and ecological systems in complex and uneven ways. The risk increases clearly under high-emission scenarios, showing that the risk to taonga species is susceptible to warming, particularly for marine species with narrow habitat thresholds. Even with lower warming, long-term change may challenge customary practices without targeted support for Māori-led responses.

Enabling tikanga-based governance systems, through frameworks such as the Mātauranga Māori Framework for Surveillance (MMFS), the tika transition model, or Indigenous data sovereignty regimes, will be essential for managing risk severity in ways that are not only technically sound but also tikanga-based (Bargh & Tapsell 2021; Sharma et al. 2024; Wood et al. 2024). While these sources outline critical pathways, their uptake in formal governance systems remains limited, and their ability to reduce risk severity at scale depends on sustained investment and policy change.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 4: Risk severity scores under different climate scenarios for loss of access to taonga species

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Loss of access to taonga species	Localised reductions in access to mahinga kai and taonga species due to land use and ecosystem degradation. Regional variability persists, but tikanga-based practices remain viable in many areas through restoration efforts.	Climate and land-use pressures increasingly restrict access to taonga species across regions, especially marine and freshwater domains. Loss of maramataka cues and taonga species begins to disrupt hauora and intergenerational practice.	Cumulative ecological degradation leads to widespread decline of taonga species across multiple environments. Customary practices and hapū/iwi well-being are severely affected, particularly where regional responses are fragmented or under-resourced.	Collapse of key taonga species populations in some rohe. Cascading effects across Māori economic, ecological, and cultural systems. Without uptake of tikanga-based governance frameworks, loss becomes near-irreversible, undermining identity and mana motuhake.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.2 Damage to Māori infrastructure

This section examines how climate change threatens significant sites such as marae, urupā, wāhi tapu, wāhi tūpuna and papakāinga, disrupting tikanga, identity, and resilience. Table 5 outlines the risk of damage to Māori infrastructure, which is increasingly vulnerable to flooding, sea-level rise, fire and extreme weather events. The table highlights how the loss or degradation of these sites poses significant economic, social, and spiritual risks for Māori communities and diminishes their capacity for climate resilience.

Table 5: Summary table for the climate risk of damage to Māori infrastructure

Risk overview	Māori infrastructure (e.g. marae, urupā, wāhi tapu, wāhi tūpuna) is foundational to Māori well-being, identity, and governance. These sites are increasingly at risk from climate-related hazards, such as flooding and erosion, particularly in historically marginalised areas. Evidence is regional, primarily with no national dataset.
Exposure (current, 2050, 2090)	Current exposure is high in flood-prone and coastal zones. Events like Cyclone Gabrielle highlight the significant risk, but no national mapping of at-risk infrastructure exists. By 2050-2090, exposure will increase with warming, especially under high-emission scenarios. Lack of data hampers planning and adaptation.
Sensitivity and adaptive capacity	Sensitivity is high due to economic, social, spiritual and community reliance on infrastructure. Adaptive capacity exists in local leadership and innovative projects, but funding, recognition, and systemic support are limited, especially on multiply owned Māori land.
Compounding and cascading factors	Damage leads to cascading impacts on identity, knowledge transfer, emergency response, and whānau resilience. Repeated disruption can result in abandonment or spiritual loss, undermining community autonomy and the sustained practice of tikanga if not addressed.
Socioeconomic trends	Infrastructure funding is fragmented and often excludes Māori institutions. Competitive, short-term grants and policy misalignment reduce Māori access to resilience investments, leading to funding insecurity and increased administrative burdens, which, in turn, increase risk.
Climate thresholds and tipping points	Biophysical thresholds may be crossed in some areas as flooding and erosion intensify. Tipping points occur when sites become uninhabitable or spiritually compromised. Māori infrastructure may lose function without retrofits or managed retreat, especially under high-emission scenarios.
Interactions with mitigation actions	Mitigation can help (e.g., low-carbon marae upgrades), but national mitigation approaches risk exclusion if Māori values are not included. Poorly planned development can worsen exposure. Māori-led mitigation offers co-benefits but needs investment to ensure Māori have equitable access and outcomes in hazard planning.
Data gaps	There is no national comprehensive inventory or exposure data on Māori infrastructure. Current adaptation frameworks do not capture spiritual and relational dimensions. Adaptive capacity and funding access remain poorly understood and untracked nationally.
Confidence level	Moderate confidence is based on strong case study agreement, but national data sets are lacking. Exposure trends and importance to Māori are well established; adaptive capacity data are limited, and relational indicators are missing in formal planning.

Marae, papakāinga, urupā (burial grounds), wāhi tapu and wāhi tūpuna (sacred and ancestral places) are foundational to Māori well-being, serving not only as physical places but also as spiritual, relational, and governance anchors. They enable ceremony, decision-making, intergenerational teaching, and the enactment of tikanga. However, these sites are increasingly exposed to climate-related risks, including flooding, erosion, sea-level rise, and storm damage. Their exposure is especially pronounced in coastal, riverine, and flood-prone areas, many of which reflect historical patterns of land alienation and infrastructure underinvestment (Awatere et al. 2021; Munro 2021; Te Rūnanga o Te Rarawa 2021; Kawharu 2023; Johnson, Fisher & Parsons 2024).

© New Zealand Institute for Bioeconomy Science Limited (2026)

The current evidence base is strongest in regional case studies and community-level reports. Research by Bailey-Winiata et al. (2024), Munro (2021), and Awatere et al. (2021) has highlighted repeated damage to marae and urupā, particularly during extreme weather events such as Cyclone Gabrielle. Te Rūnanga o Te Rarawa (2021) further documented flooding, dune erosion, and wastewater overflow near marae and papakāinga in the Awanui catchment, exacerbating structural and spiritual integrity risks. However, no national data set maps the condition, location, or hazard exposure of Māori infrastructure. Consequently, the full extent of the risk remains under-recognised in official planning systems (Kawharu 2023).

While many marae have demonstrated their role as emergency hubs for large communities affected by extreme weather, these significant sites often lack adequate insurance, retrofitting, or funding to recover from damage. Awatere et al. (2021) provided case-based confirmation of insurance and maintenance challenges, but did not offer national-scale conclusions, which indicates a need for caution in generalising those findings. Similarly, evidence from Stephenson, Rewi et al. (2023) referred to specific instances, such as Ngā Ariki relocating a whare (home) due to repeated flooding, yet did not quantify the number or proportion of at-risk sites. It is therefore important to frame such examples as illustrative rather than representative.

Kawharu (2023) further noted that marae and kāinga are often excluded from critical infrastructure inventories and resilience planning, which limits their visibility in funding systems. This exclusion is compounded by legal and financial barriers that prevent many Māori communities from accessing adaptation funding, especially for multiply owned land or sites not formally recognised within infrastructure regimes. Johnson, Fisher & Parsons (2024) demonstrated that repeated damage or inaccessibility can reduce the ability of marae and wāhi tapu to fulfil their roles, undermining spiritual well-being and intergenerational knowledge transfer. This supports the need to recognise these sites as Māori infrastructure of national importance.

Compounding the physical risks are spiritual, social and economic consequences. Damage to urupā, for example, can result in the disinterment or relocation of tūpuna, an act associated with profound emotional and spiritual trauma (Masters-Awatere, Young, Graham 2022). Repeated disruption may eventually render a site unviable – functionally, financially, or spiritually – leading to a tipping point where infrastructure no longer supports community cohesion or sustained practice of tikanga. The Deep South Challenge (2024) noted that whare tūpuna should be understood as living structures that carry whakapapa and mana, meaning their loss entails more than structural degradation, and represents the erosion of tikanga.

Several research sources, such as Pohatu & Walker (2021) and case study reports from Our Land and Water NSC challenges (Our Land and Water 2021), have highlighted how impacts from river engineering and land-use change, including sedimentation, have damaged wāhi tapu and wetlands, severing traditional access routes and compromising the mauri of place. However, these insights are based on selected catchments (e.g., Te Tauihu, Waiapu) and should not be considered comprehensive assessments. The pattern is clear, but it has not yet been nationally quantified.

3.2.1 Exposure – current, 2050 and 2090

Māori infrastructure, including marae, papakāinga, urupā, wāhi tapu, and wāhi tūpuna, is increasingly exposed to climate-related hazards such as flooding, erosion, sea-level rise, storm surge, and sedimentation. This exposure is especially pronounced in coastal, low-lying, and flood-prone areas. These may include lands that were historically marginalised through colonisation and land alienation (Awatere et al. 2021; Munro 2021; Kawharu 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Events such as Cyclone Gabrielle have illustrated this vulnerability. Damage to marae, urupā, and surrounding infrastructure was documented in Te Matau-a-Māui (Hawke's Bay), where Māori enterprises experienced significant structural and financial impacts (Envirostrat Limited 2024). Harrington et al. (2023) projected that such events will intensify under all emissions pathways, underscoring the need for early, Māori-led adaptation to protect critical sites and infrastructure. Importantly, national mapping of marae and kāinga vulnerability has not yet been undertaken.

In catchments such as those of the Waiapu River (near Gisborne) and those at the top of the South Island (Te Tau Ihu), river engineering, sedimentation, and forestry runoff have exacerbated erosion and increased flood risk, impacting wāhi tapu and downstream marae (Our Land & Water 2021; Pohatu & Walker,2021). In Te Hiku o Te Ika (Northland), the Te Rarawa cultural impact assessment (Te Rūnanga o Te Rarawa 2021) noted that coastal erosion, dune destabilisation, and urban wastewater overflows continue to damage infrastructure near marae and papakāinga, particularly in low-lying wetland zones. This demonstrates exposure to both acute and chronic stressors in already vulnerable landscapes.

By 2050, under warming scenarios of 1.5°C–2°C, intensified rainfall events, flash flooding, and extreme weather are expected to increase the frequency and severity of exposure for Māori infrastructure in some areas. Sites in low-lying or coastal locations are projected to face growing risks of structural degradation, access disruption, and repeated inundation. Relocation planning is already under way in some areas, but available examples, such as the Ngā Ariki relocation noted by Stephenson, Rewi et al. (2023), are illustrative rather than more broadly represented. Masters-Awatere et al. (2022) also described the emotionally traumatic effects of the relocation of urupā due to ongoing flood exposure.

By 2090, with warming reaching 2.5°C–3.5°C, coastal inundation and storm surge may render some significant sites unsafe or uninhabitable without major protection, redesign, or managed retreat. However, the scale and location of future impacts will depend on regional climate effects, land-use planning decisions, and the extent of investment in Māori-led adaptation.

Significant uncertainty remains. No centralised data set comprehensively maps marae or urupā by exposure or structural condition. Hazard models typically used in local government planning rarely incorporate Māori-defined infrastructure or vulnerability metrics (Awatere et al.,2021; Kawharu 2023). This limits visibility in adaptation planning and prevents risk-based prioritisation.

3.2.2 Sensitivity and adaptive capacity

Māori sensitivity to damage of Māori infrastructure is high due to the central role that marae, papakāinga, urupā, and wāhi tapu play in identity, governance, ceremony, and intergenerational well-being. These sites are not merely buildings; they are physical embodiments of whakapapa, tikanga, and community cohesion (Munro 2021; Johnson, Fisher & Parsons 2024; Bailey-Winiata et al. 2024; Deep South Challenge 2024). Their degradation or loss disrupts tikanga and relational networks that uphold mana motuhake and collective resilience.

This sensitivity is amplified by many of these sites being in vulnerable locations such as coastal edges, riverbanks, and flood-prone plains. In some cases, this exposure reflects historical patterns of land marginalisation, where Māori were left with land parcels least suited to development or protection (Awatere et al. 2021; Kenney & Phibbs 2021; Whitehead & Walker 2021). Cyclone Gabrielle highlighted this risk, with widespread damage to Māori infrastructure in regions including Te Matau a-Māui (Hawke's Bay) and Te Tairāwhiti (East Coast) (Envirostrat Limited 2024). However, this literature is drawn primarily from regionally focused case studies and disaster reporting.

© New Zealand Institute for Bioeconomy Science Limited (2026)

When Māori infrastructure is compromised, the consequences extend beyond physical damage. The relocation or restriction of use of urupā or whare tīpuna, for example, can generate emotional distress and spiritual dislocation for affected whānau (Kenney & Phibbs 2021; Masters-Awatere, Young, Graham, 2022). Tapsell (2022) noted that when tikanga-based relationships to place are disrupted by climate-related damage, the result may be systemic harm to whanaungatanga and kaitiakitanga. However, while qualitative data support these insights, national-level sensitivity metrics for Māori infrastructure do not yet exist.

Māori adaptive capacity in this area is visible but uneven. Whānau and hapū have demonstrated strong local leadership, particularly in disaster response, where marae often serve as first-response hubs offering shelter, coordination, and support (Cram 2021). However, Kawharu (2023) have pointed out that most kāinga remain without climate action plans and lack formal links with local authorities, limiting their access to adaptation funding or infrastructure support.

There are promising examples of Māori-led innovation in tikanga-based infrastructure design, such as the Living Pā project and climate-resilient marae retrofits (Hall et al. 2024). These initiatives show that Māori-led models can successfully integrate sustainability, resilience, and tikanga when resourced. Nevertheless, these cases remain the exception. Access to funding is often constrained by incompatible eligibility criteria, particularly for land that is multiply owned or collectively governed (Berghan 2021; Andersen 2024). Mannakkara et al. (2023) observed that limited integration of Indigenous leadership in infrastructure design and climate governance settings impedes adaptive efforts, especially where Māori infrastructure lacks recognition as being critical to community well-being.

Uncertainty in this domain stems from the lack of comprehensive data on infrastructure condition, hazard exposure, and significance to Māori. Many marae and kāinga are absent from critical infrastructure inventories, and their spiritual or relational functions are not reflected in standard risk assessments (Awatere et al. 2021; Kawharu 2023). This limits the visibility of Māori adaptive needs in formal climate planning.

3.2.3 Compounding and cascading factors

Damage to Māori infrastructure, exacerbates and amplifies other climate risks, especially those affecting identity, governance, and well-being. These sites are often situated in low-lying or erosion-prone areas and are increasingly exposed to flooding, sedimentation, and storm surge (Awatere et al. 2021; Te Rūnanga o Te Rarawa 2021; Bailey-Winiata et al. 2024). When repeatedly damaged, these sites can lose their functional capacity to host community gatherings, coordinate emergency response, or maintain tikanga (Munro 2021; Kawharu 2023).

This infrastructure loss can trigger cascading risks across social and economic domains. The relocation or damage to marae complexes, urupā, or whare tīpuna causes emotional trauma to whānau (Masters-Awatere, Young, Howard, et al., 2022). This, in turn, disrupts marae-based decision-making processes and collective care networks because meeting spaces, records/taonga, utilities, and tikanga-anchored roles are displaced. In turn, this weakens whānau cohesion and reduces community autonomy, particularly in emergencies (Cram 2021; Johnson, Fisher & Parsons 2024; Bush International Consulting 2024).

Over time, these disruptions may lead to the erosion of intergenerational knowledge transmission and tikanga-based governance. Repeated physical and emotional strain can accelerate dependency on external systems, such as state-based emergency services, especially where formal adaptation planning does not recognise or resource the role of marae and kāinga as critical infrastructure (Munro 2021; Kawharu 2023). While not all infrastructure is equally vulnerable, the

© New Zealand Institute for Bioeconomy Science Limited (2026)

compounding effects of exposure, funding gaps, and exclusion from infrastructure funding and policy increase the overall risk of displacement.

The loss of Māori infrastructure may amplify identity loss and reduce participation of rangatahi in community life (Ratana 2023; Bailey-Winiata et al. 2024). The decline in regular use of marae for pōwhiri, tangihanga, and hui diminishes access to places where te reo Māori, karakia, and customary protocols are taught and maintained. This erosion of tikanga is not just symbolic; it can weaken the bonds that hold whānau together. This is especially true when changes are led by outsiders or when the process excludes whānau (Erueti et al. 2023).

Where Te Tiriti-aligned adaptation is absent, these cascading effects may intersect with housing insecurity, displacement, and economic precarity, compounding climate-related harm across multiple domains. As significant sites lose functionality or are abandoned, their loss may initiate a tipping point in the sustained practice of tikanga and intergenerational well-being, especially when relocation is not accompanied by support for restoration or reconnection.

3.2.4 Socioeconomic trends that may exacerbate the risk

One key socioeconomic trend that may exacerbate damage to Māori infrastructure is the ongoing marginalisation of marae, kāinga, and urupā in public infrastructure planning and investment frameworks. Many marae and kāinga appear to remain outside the scope of formal resilience – or lifeline infrastructure – systems, which limits access to adaptation and recovery funding (Kawharu 2023). The funding environment for Māori infrastructure is often characterised by short-term, competitive grants that can exclude multiply owned land or kaupapa Māori institutions (Berghan 2021). This design misaligns with long-term Māori planning horizons and introduces administrative burdens that some whānau and hapū are not resourced to meet (Cram 2021; Kawharu 2023).

Mannakkara et al. (2023) highlighted how eligibility barriers and fragmented planning processes often exclude Māori infrastructure from community resilience funding, despite these sites being central to social cohesion and disaster response. This issue is particularly acute in regions with limited planning staff or no designated liaison with hapū or marae. Economic funding insecurity also limits opportunities for proactive upgrades, increasing reliance on emergency repairs that may not be durable in the long term; and limits opportunities for volunteer-based recovery (Munro 2021; Envirostrat Limited 2024). Māori collectives risk becoming locked in a reactive maintenance cycle without core baseline funding. The cumulative effect of these pressures undermines community autonomy and reduces the capacity to withstand repeated climate shocks (Masters-Awatere, Young, Graham, 2022; Bush International Consulting 2024).

3.2.5 Climate thresholds and tipping points

The severity of risk to Māori infrastructure, is strongly influenced by biophysical and engineering thresholds related to site exposure and structural resilience. Thresholds may be crossed when flood levels, storm surge heights, or erosion rates exceed the physical capacity of these sites to remain accessible, safe, or habitable (Awatere et al. 2021; Bailey-Winiata et al. 2024). Many such sites were established long before modern building codes, and are in coastal or flood-prone areas, where even a modest sea-level rise or increased storm frequency could overwhelm existing infrastructure without retrofitting or protection. Insurance access, funding thresholds, and eligibility criteria, particularly for multiply owned land, also represent policy barriers that, if not addressed, may inhibit adaptation and compound vulnerability (Munro 2021; Kawharu 2023). The timing and severity of damage to Māori infrastructure will be influenced by local exposure and emissions pathways. While the NCCRA does not specify exact thresholds under RCP (representative

© New Zealand Institute for Bioeconomy Science Limited (2026)

concentration pathway) scenarios, evidence suggests that without proactive adaptation, many marae and urupā in flood-prone or low-lying areas could face increasing risk of physical degradation or inaccessibility within the coming decades (Awatere et al. 2021; Bailey-Winiata et al. 2024; Deep South Challenge 2024; Stephenson, Kawharu et al. 2023).

A potential tipping point may occur when repeated damage renders Māori infrastructure non-viable, physically, financially, or spiritually. For example, if a marae is inundated multiple times and cannot be insured, repaired, or relocated in a tikanga-based way, it may lose its role as a living centre of whānau identity, ceremony, and governance (Te Puni Kōkiri 2023; Deep South Challenge 2024). Johnson, Fisher & Parsons (2024) showed that losing wāhi tapu to erosion or access barriers weakens these places' spiritual and relational functions, leading to cumulative harm and a loss of mana-enhancing confidence among younger generations. This could disrupt community cohesion and diminish intergenerational knowledge transmission. The erosion of urupā or destruction of wāhi tapu may also result in irreversible damage to spiritual well-being and hapū/iwi well-being. While isolated damage can be addressed, the cumulative effect of repeated exposure, especially in the absence of investment and Te Tiriti-consistent managed retreat pathways, risks a shift in the function and meaning of these sites. Te Rūnanga o Te Rarawa (2021) noted that some marae and papakāinga were already at a threshold where degraded water systems, repeated flooding, and insufficient investment had reduced both physical safety and function, triggering discussion of relocation even in the absence of formal support. The likelihood of such tipping points increases under higher warming scenarios or continued policy inaction.

3.2.6 Possible interactions with climate mitigation actions

Climate mitigation actions, particularly those related to land-use change, infrastructure upgrades, and emissions reduction in construction, can interact positively and negatively with the risk of damage to Māori infrastructure. Low-carbon building initiatives and increased investment in climate-resilient infrastructure could reduce the vulnerability of marae, papakāinga, and kāinga to climate hazards if such investments include Māori sites and are designed in tikanga-based ways (Andersen 2024; Hall et al. 2024). For example, retrofitting marae using sustainable materials and passive cooling/heating principles could reduce emissions and enhance resilience to heatwaves or storms (Hall et al. 2024). However, if mitigation efforts focus narrowly on decarbonisation without recognising the multifunctional and spiritual roles of Māori infrastructure, Māori sites may again be excluded from funding eligibility or design standards (Tapsell 2022; Kawharu 2023).

In some cases, mitigation actions could unintentionally increase exposure. For instance, poorly located, large-scale pine afforestation or infrastructure development may restrict access to (or alter) the landscape around significant sites (Rout & Walker 2021; Ministerial Inquiry into Land Use 2023). Similarly, when marae are located outside urban centres or designated renewal zones, their infrastructure needs may be overlooked in emissions-reduction planning (Munro 2021). Te Rūnanga o Te Rarawa (2021) raised concerns that water infrastructure upgrades driven by climate-resilience goals have sometimes bypassed papakāinga and marae, further entrenching environmental inequity and climate exposure for local Māori communities.

Climate change may also complicate mitigation delivery, as repeated damage to significant sites could strain community capacity and divert attention away from participating in local or regional climate planning processes (Cram 2021; Envirostrat Limited 2024). Conversely, where mitigation is Māori-led, such as in projects integrating renewable energy with whānau housing or marae retrofits, there is potential to generate co-benefits that reduce emissions while strengthening community resilience (Berghan 2021; Tai-o-Rongo Research Collective 2024). Ensuring mitigation

© New Zealand Institute for Bioeconomy Science Limited (2026)

efforts are Te Tiriti-consistent and tikanga-based will be key to aligning outcomes across mitigation and adaptation domains (Bargh & Tapsell 2021; Kawharu 2023).

3.2.7 Data gaps

Substantial data gaps affect the assessment of Māori exposure, sensitivity, and adaptive capacity related to Māori infrastructure. While isolated case studies document damage to marae, urupā, and papakāinga, particularly during extreme events like Cyclone Gabrielle, there is no comprehensive national data set mapping the location, condition, or climate exposure of Māori infrastructure (Awatere et al. 2021; Bailey-Winiata et al. 2024). Existing infrastructure risk assessments and regional plans often exclude marae and kāinga from critical infrastructure inventories, limiting visibility in funding and planning systems (Kawharu 2023). Sensitivity is also under-measured, particularly about these sites' spiritual and relational functions, which are not accounted for in conventional asset or impact assessments (Tapsell 2022; Tai-o-Rongo Research Collective 2024).

Adaptive capacity is similarly under-represented in existing data sets. Although many Māori communities have demonstrated strong leadership in disaster response and local infrastructure planning, information on insurance access, retrofit readiness, or funding eligibility is not systematically collected by hapū/iwi organisations, industry bodies or government agencies (Cram 2021; Munro 2021). Consequently, assessing the preparedness of different marae or kāinga for projected hazards remains challenging, especially at a national scale. Sharma et al. (2024) also noted the lack of geospatial data systems that uphold Māori data sovereignty, which further limits the local community's ability to plan by tikanga.

The absence of mātauranga-informed indicators, or tikanga-based decision making, in mainstream climate risk tools also means that the relational dimensions of risk remain invisible, primarily to policymakers (Erueti et al. 2023). This omission reinforces a structural gap between Māori realities and the metrics used in adaptation funding, hazard mapping, or infrastructure prioritisation.

3.2.8 Confidence level

The overall confidence in the evidence base for this risk is moderate, due to the combination of strong qualitative agreement and limited national coverage. Numerous sources, including Awatere et al. (2021), Kawharu (2023), and Masters-Awatere, Young, Graham et al. (2022), have provided compelling regional evidence and case studies of marae, papakāinga, and urupā that have been exposed to flooding, erosion, and structural decline. These studies confirmed the centrality of Māori infrastructure to Māori well-being, governance, and whanaungatanga.

For Māori, these places serve ceremonial, governance, and emergency roles, and that their degradation carries both material and social consequences (Berghan 2021; Cram 2021; Johnson, Fisher & Parsons 2024). However, quantitative, nationally aggregated data are lacking, including a complete Māori infrastructure inventory, as well as information on hazard exposure, insurance status, and condition (Sharma et al. 2024). Most local or central government adaptation plans and resilience frameworks do not monitor tikanga-based indicators or systematically account for tikanga-based adaptive responses (Tai-o-Rongo Research Collective 2024). While confidence is high regarding exposure trends and the significance of these sites, it is lower for adaptive capacity and risk readiness. This seems due to, for example, the absence of national metrics and the limited inclusion of Māori-led adaptation initiatives in formal planning processes. Consequently, the actual severity and systemic nature of this risk may be underestimated in national infrastructure and emergency systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.2.9 Risk severity summary

Table 6 presents the risk severity criteria for damage to Māori infrastructure across four levels of risk, from minor to extreme. It draws on published literature to assess how exposure to climate hazards, uneven investment, and lack of culturally aligned planning may undermine the resilience of marae, papakāinga, and other kaupapa Māori facilities over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 6: Risk to Māori Infrastructure risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Minor localised damage functionality can be restored through existing systems. • Tikanga and ceremonial use remain intact.	• Moderate or recurring damage to multiple sites; repairable but financially and emotionally burdensome. • Tikanga intermittently disrupted.	• Severe or persistent damage to significant Māori infrastructure • Sites become uninhabitable or unusable without major intervention.	• Near-total loss of function for marae, urupā or wāhi tapu. • Managed retreat or abandonment without tikanga-consistent pathways. Tikanga dislocated.
Extent, duration and frequency of likely impacts	• Minor disruption to marae, urupā or papakainga • Public trust and community cohesion remain strong.	• Repeated damage causes loss of access or temporary closure of critical sites. • Confidence in recovery declines.	• Cascading disruptions to identity, governance, and ceremony. • Marae decision-making and whānau-based resilience weaken.	• National-scale loss of intergenerational identity and cohesion. Governance breakdown in communities reliant on key sites.
Ability to recover from likely impacts	• Infrastructure can be repaired using existing funding or insurance mechanisms; no systemic damage to tikanga or cohesion.	• Whānau capacity stretched. • Repairs require new funding or planning pathways. • Some emotional/spiritual harm	• Significant delays or failures in rebuilding due to planning exclusions, insurance gaps, or poor alignment with tikanga.	• Failure to rebuild. • Dislocation causes deep trauma • Adaptive capacity overwhelmed.
Likely equity impacts	• Planning and support systems are inclusive • Decision-making is tikanga-aligned.	• Funding gaps or exclusion from climate planning emerge. • Sites with complex tenure face delays or limited access to resilience funding.	• Māori communities disproportionately affected due to systemic exclusion • Recovery access remains inequitable.	• Deepening of structural inequity. • Displacement and funding failures • Tikanga excluded from all planning stages.
Likely impacts on te ao Māori	• Māori-led responses proceed unhindered. • Restoration is resourced well. • Impacts are small-scale and reversible.	• Tikanga is strained. • Some rituals disrupted. • Restoration occurs slowly, with few tikanga-based indicators used.	• Spiritual connection to places are compromised. • Wānanga, tangihanga, on marae and intergenerational transmission of knowledge decline sharply.	• Spiritual ties to whenua severed. • Cultural practices collapse. • No recognition or support for tikanga-grounded recovery.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 7) elaborates on the projected severity of damage to Māori infrastructure under different warming scenarios. We utilised the Commission's scoring template for compiling our risk severity scores (see Appendix 3). It draws on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. By mid-century (i.e. 1.5°C –2°C warming), the frequency of damaging events, such as floods and storms, will likely have increased, raising the risk of functional loss of infrastructure or temporary disconnection between Māori and their infrastructure. However, these impacts may differ across the country depending on whether areas become warmer and wetter or drier and more fire-prone. Repeated damage could make some sites unsafe or unviable by the end of the century (i.e. 2.5°C–3.5°C warming), especially without coordinated investment or tikanga-aligned retreat options.

Cumulative impacts may also compound across regions, with diverse effects where damage thresholds are surpassed, or essential infrastructure is lost. The risk becomes more severe under higher warming scenarios, with greater exposure and fewer recovery options. Without action, loss of Māori infrastructure could lead to broad social and economic impacts that would be difficult to reverse. Uncertainty remains in our assessment due to data gaps on site condition, hazard mapping, and the pace of climate-induced change, but the potential for irreversible loss warrants precautionary and locally tailored planning.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 7: Risk severity scores under different climate scenarios for Māori infrastructure

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Māori infrastructure	Many marae, papakāinga, and urupā face heightened exposure to flooding, erosion, and storms, but some resilience remains where local planning and maintenance systems are in place. Data gaps limit national coordination.	More frequent climate events increase the risk of damage, disconnection, or unsafe conditions. Impacts vary by region and hazard type. Sites with limited funding or repair capacity may experience prolonged disruption.	Repeated exposure to hazards undermines infrastructure viability in multiple regions. Cascading failures may emerge where critical services or Marae are compromised. Lack of investment in Māori-led resilience accelerates decline.	Sustained climate impacts lead to widespread, irreversible damage to Māori infrastructure. Loss of marae, papakāinga, and other cultural assets contributes to systemic disconnection, social fragmentation, and long-term loss of hapū/iwi identity and function.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.3 Economic losses in primary industries

This section explores how climate change affects farming, forestry, fisheries, and aquaculture, undermining Māori economic resilience, livelihoods, reinvestment capacity, and intergenerational equity. Table 8 summarises the economic losses facing Māori in these climate-sensitive primary industries. It highlights how climate impacts, from cyclones to biosecurity threats, disrupt whānau livelihoods and limit reinvestment in whenua-based development.

Table 8: Summary table for the climate risk of economic losses in primary industries

Risk overview	Māori economic activity is concentrated in climate-sensitive sectors like farming, forestry, aquaculture, and fisheries. Climate hazards disrupt income, food sovereignty, and tikanga-based roles, especially for wāhine Māori and whānau-based enterprises. Formal Māori enterprises and informal economies alike face climate and institutional challenges.
Exposure (current, 2050, 2090)	Exposure is rising due to floods, droughts, biosecurity threats, and marine changes in some areas. Māori enterprises face barriers to insurance, recovery funding, and infrastructure, particularly on multi-ownership land. Regional and sectoral variation adds complexity. Informal Māori economies are especially vulnerable due to a lack of formal recognition in policy.
Sensitivity and adaptive capacity	Sensitivity is high due to marginal land, collective models and goals. Adaptive capacity exists through mātauranga-led practices and innovation, but is constrained by access to finance, digital infrastructure, and policy misalignment. Informal and non-market Māori economies are particularly under-supported by current resilience and funding systems.
Compounding and cascading factors	Economic disruption affects food systems, housing, tikanga-based mentoring, and governance. Losses in taonga species and ecosystems can trigger cascading impacts on mātauranga Māori, rangatahi employment, and intergenerational well-being. Both formal and informal economies experience knock-on effects across social, cultural, and economic systems.
Socioeconomic trends	Financial systems often exclude Māori collective models, resulting in poor data access, limited planning support, and digital exclusion, which reduce Māori capacity for climate reporting and investment. Colonially embedded tenure systems and market exclusion increase vulnerability. Informal Māori economies remain mostly invisible in adaptation funding and the economy.
Climate thresholds and tipping points	Physical and policy thresholds (e.g., shellfish mortality, uninsurable land, or regulatory burdens) may be exceeded. Tipping points could see a Māori withdrawal from primary industries, or erosion of mātauranga Māori and intergenerational economic planning. Informal systems are at heightened risk due to persistent underinvestment and exclusion from climate finance.
Interactions with mitigation actions	Mitigation may provide opportunities (e.g., regenerative land use) or risks (e.g., afforestation displacing kai production). Current policy biases (e.g., Emissions Trading Scheme (ETS)) disadvantage native ecosystems and tikanga-aligned land use. Māori-led innovations need better alignment with finance systems. Māori-led innovations, formal and informal, need better alignment with emissions finance and mitigation tools.
Data gaps	Limited disaggregated data for Māori enterprises. Mātauranga-informed indicators, access to adaptive finance, and spatial risk data are lacking. Existing frameworks undervalue relational, intergenerational resilience and exclude kaupapa Māori economic measures. Informal enterprises are especially poorly documented.
Confidence level	Moderate confidence. Exposure patterns are well-evidenced, but adaptive capacity and tikanga-based risk metrics are poorly captured: te ao Māori data exclusion limits visibility of Māori vulnerability in national systems. Informal economies are almost entirely excluded.

This section and its analyses cover both taonga species–based enterprises and broader Māori participation in conventional primary industries, including farming, forestry, and aquaculture. While several examples reflect tikanga-aligned economic models, the analysis also addresses commercial Māori enterprises operating in market-based sectors. The evidence base is drawn from literature and reports published between 2021 and 2025. However, we acknowledge that Māori economic exposure extends further, particularly through large-scale iwi investment portfolios that may not always be captured within taonga or tikanga frameworks. For instance, Te Rūnanga o Ngāi Tahu Groups' (2024) annual report 2023–2024 report identified that 33% of their NZ$2 billion

© New Zealand Institute for Bioeconomy Science Limited (2026)

asset base is in primary industries. Future assessments should aim to include a broader spectrum of Māori enterprise data to account for exposure across the commercial domain fully.

Many Māori economic activities are concentrated in climate-sensitive sectors like farming, forestry, fisheries, and aquaculture. Droughts, floods, ocean acidification, and new biosecurity risks threaten the viability of these investments, undermining the economic resilience of whānau and the ability to reinvest in community development. While not always the central focus, financial insecurity is a common theme across multiple reports, especially where damaged infrastructure limits productive capacity. Envirostrat Limited (2024) detailed how Māori businesses, especially in horticulture, fisheries, and forestry, faced prolonged operational disruptions after Cyclone Gabrielle. This included challenges such as sedimentation and loss of access roads. In districts such as Gisborne, Wairoa, and Hastings, widespread landsliding occurred following Cyclone Gabrielle, with the total number of landslides exceeding 300,000 and large volumes of productive soil deposited on floodplains. In the Esk River catchment, approximately 1.5 million tonnes of sediment were deposited at an average depth of 80 cm (McMillan et al. 2023). Barriers such as limited insurance access for whenua Māori compound recovery challenges for Māori landowners, particularly where land tenure, infrastructure, and market factors intersect (Ministerial Inquiry into Land Use 2023; Mika & MacDonald 2024). Johnson, Fisher and Parsons (2023) further highlighted that for wāhine Māori working in land-based roles, these climate-related disruptions affect not only income but also their capacity to uphold collective responsibilities such as food provisioning, mentoring rangatahi, and maintaining whenua-based knowledge systems.

Climate-related disruptions also broadly affect Māori agrifood systems, threatening kai sovereignty (food sovereignty) and the integrity of tikanga-based land-use practices. Māori landowners face compounding pressures from climate change and regulatory uncertainty, which complicate decision-making and reduce access to financial and technical resources (Percy et al. 2024). These pressures affect both formal Māori economies, such as agribusinesses and aquaculture enterprises operating within conventional regulatory and financial systems, and informal economies, which encompass customary food practices, whānau-based distribution networks, and non-market systems grounded in tikanga. For instance, changes in rainfall, biodiversity loss, and infrastructure strain undermine mahinga kai and the capacity of whānau to enact kaitiakitanga (Tai-o-Rongo Research Collective 2024).

The informal economy, although often invisible in national accounting, provides essential food security, cultural continuity, and reciprocal obligations within hapū and marae communities. Following Cyclone Gabrielle, sedimentation and debris from hill country erosion damaged low-lying food production zones and mahinga kai. The Waipaoa and Waiapu catchments, culturally and economically significant to Māori communities, were among the most affected areas, with mapped landslide scarring exceeding 4–5 km² in each catchment and some local zones recording high landslide density (McMillan et al. 2023). The erosion of tikanga-informed farming, aquaculture, and food distribution networks creates cascading risks across both commercial Māori enterprises and whānau-centred economies (Hutchings et al. 2020; Reid et al. 2023), undermining Māori economic resilience in both formal and informal domains.

Māori aquaculture and fisheries enterprises are concentrated in high-risk sectors such as shellfish farming and reef fisheries. Rising temperatures, altered hydrodynamics, and biosecurity threats are increasingly affecting pāua, kūtai, seaweed, and flatfish (i.e. flounder and sole) aquaculture (Howarth & Major 2023; Skelton et al. 2023). Projects trialling biodegradable spat-catching materials report storm damage, sedimentation, and marine fauna interference as operational challenges (Skelton et al. 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

In associated sectors, such as ecotourism, Māori-led operators face growing uncertainties due to extreme weather and shifts in marine ecosystems, all of which compromise the viability of low-impact, values-based business models (Lück et al. 2024). These impacts increase financial exposure and limit whānau-based economic planning, particularly where strategies are grounded in intergenerational resilience and tikanga-aligned enterprises. Food supply chains (from farm to shelf) now prioritise climate resilience and traceability. When assurance and finance systems exclude Māori values, investment rules and product standards do not match Māori practices. The result is less capital for adaptation and more barriers to meeting market requirements, reducing Māori market access (Mitchell & Seymour 2023; Rout & Whitehead 2023).

Māori, especially rangatahi, are concentrated in climate-exposed primary industries (horticulture, fisheries, forestry), often in non-Māori-owned firms where they have little say over adaptation investments. When floods, storms, or supply-chain shocks hit, the result is shorter hours, seasonal downtime, lay-offs, and casualisation. These shocks land hardest on Māori who already face systemic barriers in training and employment (Paul & Rātana, 2022; Paul 2023), increasing income volatility and unemployment spells in affected regions. These income shocks can also spill over into housing security and whānau stability (Cram 2021).

3.3.1 Exposure – current, 2050 and 2090

Māori enterprises are involved in various primary sectors, including agriculture, forestry, fisheries, aquaculture, and eco-cultural tourism. These industries face increasing exposure to climate-related stressors. Māori economic exposure reflects physical vulnerabilities and broader structural conditions, including land tenure systems, financial access, and infrastructure quality (Whitehead & Walker 2021; Paul & Rātana, 2022; Kingi et al. 2023; Paul 2023). While these formal Māori enterprises operate within conventional regulatory and market frameworks, they are closely interwoven with informal economic systems based on tikanga, including customary harvesting, reciprocal food sharing, and whānau-led production. For instance, Māori collectives in coastal areas face increasing risks from sedimentation and erosion, while inland forest and food systems experience more frequent drought events that misalign with maramataka and traditional planting cycles (Apiti et al. 2023; Tai-o-Rongo Research Collective 2024). Johnson, Fisher & Parsons (2024) also observed that degraded mahinga kai and water systems reduce the reliability of mahinga kai harvests, undermining both the viability of tikanga-aligned enterprise planning in the formal sector and the resilience of whānau-centred, non-commercial economies.

In areas such as northern Hawke's Bay and upper Wairoa, exotic forestry and grassland systems were more susceptible to landsliding than indigenous forest during Cyclone Gabrielle. A report by McMillan et al. (2023) noted that exotic forestry was less effective than expected in reducing landslide probability, particularly where land had experienced repeated forestry rotations or long-term erosion. In contrast, indigenous forests generally maintained higher effectiveness in reducing slope failure (McMillan et al. 2023). This pattern is significant given that Māori landholdings are concentrated in regions such as Te Tairāwhiti (East Coast), where hill country farming and plantation forestry are common (Whitehead & Walker 2021).

McMillan et al. (2023) also noted that exposure to landslides was highest on high-producing grassland and harvested exotic forest, which are land covers prevalent in many areas with Māori economic interests. Where land use is already constrained by slope and soil limitations, the reduced effectiveness of erosion control increased the likelihood of future sediment loss and damage to productive areas, particularly during severe weather events (McMillan et al. 2023). These impacts may limit the reliability of land-based enterprises in exposed regions. They may also place added pressure on decision making around land use, particularly in communities where

© New Zealand Institute for Bioeconomy Science Limited (2026)

informal subsistence economies rely on continuity of access to productive whenua and where commercial investment is shaped by collective governance constraints (Kingi et al. 2023; Mika & MacDonald 2024).

Recent extreme weather events have highlighted current vulnerabilities. In Hawke's Bay (Te Matau-a- Maui), Māori aquaculture and horticulture operators experienced extended shut-downs due to sedimentation, infrastructure failure, and lack of insurance coverage following Cyclone Gabrielle (Envirostrat Limited 2024). These incidents have highlighted the challenges Māori collectives face in accessing structured recovery support, particularly when land is held in multiple ownership or when customary governance structures do not align easily with standard funding mechanisms (Ministerial Inquiry into Land Use 2023; Mika & MacDonald 2024). McMillan et al. (2023) also noted how extensive sediment deposition occurred on productive floodplains in catchments such as the Esk and Ngaruroro, further disrupting horticultural operations and recovery pathways (McMillan et al. 2023)

Projections to mid-century (c. 2050), under approximately 1.5°C–2°C of global warming, suggest that Māori primary industries may face more variable rainfall, increased drought frequency, and changes in seasonal rhythms, conditions that may affect agricultural productivity and aquaculture viability (Percy et al. 2024; Tai-o-Rongo Research Collective 2024). These disruptions could undermine maramataka-based planning and kai production, disrupting both commercial operations and tikanga-aligned, whānau-driven practices that rely on seasonal rhythms and ecosystem signals.

While maramataka systems are inherently adaptive and may evolve in response to changing environmental cues, rapid or extreme climate shifts risk decoupling these systems from tohu (signs) grounded in species behaviours, lunar cycles, or seasonal rhythms, especially where those indicators become less predictable or disappear altogether. Marine-based enterprises, particularly those involving pāua, kūtai, and flatfish aquaculture, are also projected to encounter increased exposure from warming seas, ocean acidification, and storm-driven habitat loss (Howarth & Major 2023; Skelton et al. 2023).

By 2090, under warming scenarios of 2°C–3.5°C, exposure may be intensified for Māori collectives operating in erosion-prone landscapes or coastal zones. Systems will be stretched, and adaptation finance is hard to access when it does not match how Māori collectives make decisions (Mitchell & Seymour 2023; Rout & Whitehead 2023; Rout et al. 2023). The exclusion of Māori values from sustainability assurance and reporting frameworks may further hinder Māori enterprises from accessing emerging climate and market resilience tools. Informal Māori economies, which are not captured in standard financial reporting, also remain structurally unsupported in climate-resilience funding models, despite their critical role in local food security, customary practices, and social cohesion (Rout & Whitehead 2023).

While some Māori-led projects in regenerative marine economies and eco-tourism illustrate adaptive potential, many remain small-scale or undercapitalised (Lück et al. 2024; Mika & MacDonald 2024). Digital and data infrastructure limitations can reduce Māori capacity to meet compliance requirements for climate finance or nature-based investment reporting (Envirostrat Limited 2024; White et al. 2021). This effect is particularly acute in informal networks where data sovereignty, oral knowledge transmission, and collective rights all complicate integration with formal adaptation systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.3.2 Sensitivity and adaptive capacity

Māori are highly sensitive to climate-related economic disruptions in primary industries due to their significant involvement in farming, forestry, fisheries, aquaculture, and eco-cultural tourism. These sectors are particularly exposed to hazards such as droughts, floods, ocean warming, and biosecurity threats, hazards that are expected to intensify under projected climate change scenarios (Berghan 2021; Awatere et al 2021; Reid et al. 2023). Sensitivity is amplified because Māori landholdings are often located in environmentally marginal or erosion-prone areas, where the adaptive options are more limited (Whitehead & Walker 2021; Envirostrat Limited 2024). Te Rūnanga o Te Rarawa (2021) highlighted the fact that many Māori-owned sites near estuaries and river mouths in Northland (Te Hiku o Te Ika) face dual exposure to saltwater incursion and sedimentation, which limits aquaculture and the viability of low-input crops. Some iwi face significant food insecurity and have reduced climate resilience because large areas of their land are landlocked and lack of access to coastal resources, which limits their ability to produce or harvest kai independently (Kingi 2008). These conditions compromise both formal Māori enterprises operating in regulated primary industries and informal economies that rely on customary food gathering, whānau-based production, and reciprocal food distribution grounded in tikanga.

A clear ecological example of such cascading economic vulnerability is the kina barrens phenomenon that has disrupted reef ecosystems and shellfish harvesting critical to customary and commercial enterprise (Skelton et al. 2023; Bulmer et al 2024). This illustrates how ecosystem degradation can affect both the productivity of formal aquaculture operations and the continuity of non-market harvesting practices, further weakening local food systems and tikanga-aligned economies.

In terms of adaptive capacity, Māori demonstrate resilience through a range of whānau and hapū-based enterprises that integrate mātauranga Māori, environmental stewardship, and innovation. Examples include kelp forest restoration, regenerative aquaculture, and maramataka-aligned farming systems (Percy et al. 2024; Tai-o-Rongo Research Collective 2024). These practices reflect strong place-based knowledge and values-based management models. They also span both the formal sector, such as small and medium-sized Māori agribusinesses, and the informal sector, including whānau-initiated food sovereignty efforts and unpaid restoration work. However, many Māori-led businesses report limited access to climate finance, data infrastructure, or market incentives that would enable scaling or long-term resilience planning (Mitchell & Seymour 2023; Rout & Whitehead 2023). This is compounded by siloed policy design that overlooks collective land tenure and relational economies (Lambert & Mark-Shadbolt 2021; Kingi et al. 2023; Sharma et al. 2024). Johnson, Fisher and Parsons (2023) observed that wāhine Māori leading community food initiatives often lack access to targeted economic recovery funding after disaster events, even when their enterprises fill vital gaps in community nutrition and well-being. These wāhine-led initiatives are often embedded within informal economies but are critical to local food access and cultural transmission.

A key constraint is the incompatibility of collective Māori land and enterprise models with competitive, short-term, and compliance-heavy funding systems. These misalignments often result in Māori collectives being excluded from adaptation finance or insurance-based recovery mechanisms (Kingi et al. 2023; Ministerial Inquiry into Land Use 2023; Andersen 2024). In addition, infrastructure vulnerabilities, such as road, water, or storage systems in rural areas, expose primary sector operations to climate disruption (Hughes et al. 2021). The fragmentation of climate-relevant data systems also hinders Māori communities' ability to forecast, plan, or meet due diligence thresholds for adaptation investment (Sharma et al. 2024). For informal Māori economies,

© New Zealand Institute for Bioeconomy Science Limited (2026)

these data gaps further obscure the value of their non-commercial production systems, diminishing visibility in national adaptation and planning efforts.

Uncertainty in this domain is moderate. While sectoral risks are well-documented, there is limited data disaggregation on how climate impacts are distributed across Māori-owned enterprises. Additionally, many economic risks depend on future market shifts, insurance availability, and regulatory developments, which are difficult to project.

Māori sensitivity in the primary sector is high due to structural, spatial, and governance-related factors. Adaptive capacity exists but is constrained by institutional settings that do not adequately reflect kaupapa Māori approaches to economic development. Strengthening both formal and informal Māori economic systems will require reforming access to finance, recognising Māori values in economic planning, and investing in infrastructure and regional capability. This includes ensuring that informal, tikanga-based practices and subsistence economies are supported and included in resilience planning and investment frameworks.

3.3.3 Compounding and cascading factors

Economic losses in Māori primary industries, particularly farming, aquaculture, horticulture, and forestry, are shaped by the compounding effects of multiple climate hazards. Droughts, floods, marine heatwaves, and sedimentation interact with infrastructure degradation, insurance gaps, and regulatory uncertainty to increase the exposure of Māori enterprises (Envirostrat Limited 2024). In regions such as Te Tairāwhiti and Te Tai Tokerau (East Coast and Northland), these risks are intensified by the geographic concentration of Māori landholdings in erosion-prone or flood-affected landscapes (Whitehead & Walker 2021). These environmental pressures are further compounded by historical underinvestment in rural infrastructure, and the systemic challenges Māori collectives face in accessing climate finance and risk management tools (Mika & MacDonald 2024; Rout & Whitehead 2023). The effects are felt across both formal Māori enterprises, such as export-focused aquaculture or forestry ventures, and informal economies grounded in customary harvesting, whānau-level production, and tikanga-based food systems.

Biosecurity risks, such as myrtle rust and kauri dieback disease, also intersect with climate hazards to accentuate threats to taonga species, mātauranga Māori, and local economies. The incursion of these diseases has disrupted both commercial sectors (e.g., mānuka honey) and community access to significant forests, further exacerbating stress on already vulnerable whānau economies (Lambert & Mark-Shadbolt 2021). These informal whānau economies are essential for maintaining food sovereignty, tikanga practice, and social cohesion.

Environmental degradation is also experienced as a disruption to tikanga. As Yletyinen et al. (2022) illustrated, the loss of access to valued species, such as shellfish, can cascade through social systems, affecting not only harvesting but also tikanga, governance, and identity. Such incursions may also impact the informal economy, especially mahinga kai and māra kai (food garden) systems, which play a critical role in sustaining culture, food security, and intergenerational identity. These impacts can occur within a few steps, meaning ecological damage rapidly erodes the resilience of hapū/iwi. Johnson, Fisher and Parsons (2023) noted that the weakening of customary harvesting due to marine ecosystem disruption affects food systems and wāhine-led tikanga-based mentoring and community nutrition responsibilities. It further illustrates how disruption to informal economies can also fracture intergenerational knowledge transmission and gendered care roles.

Economic disruption may also contribute to downstream risks in social, health, and governance domains. For example, when land-based and marine-based enterprises become inoperable due to

© New Zealand Institute for Bioeconomy Science Limited (2026)

climate events, as observed following Cyclone Gabrielle, Māori whānau may experience reduced income, food insecurity, or delays in community investment (Andersen 2024; Envirostrat Limited 2024). Economic stress may limit the ability of Māori collectives to maintain marae, support rangatahi development, or invest in resilience initiatives. Where enterprises depend on taonga species such as pāua or kūtai, ecosystem changes may intersect with the risk of knowledge erosion or declining tikanga practice (Skelton et al. 2023; Percy et al. 2024).

Mātauranga Māori loss is also a concern. Research on disaster risk reduction and biodiversity management has found that environmental change diminishes the use and transmission of local knowledge, especially when coupled with limited resourcing for Māori-led institutions (Lambert & Mark-Shadbolt 2021; Erueti et al. 2023). Mannakkara et al. (2023) further highlighted that community-driven innovations for food and ecological resilience are vulnerable to burnout and losing momentum after shocks, without dedicated institutional support. This is particularly true for informal economies where labour is unpaid or undercompensated, and where relational obligations drive participation without financial backing. While many Māori entities exhibit strong intergenerational planning frameworks, the convergence of economic loss with institutional funding constraints can challenge long-term resilience. This is particularly true when climate shocks are followed by slow or fragmented recovery support (Ministerial Inquiry into Land Use 2023; Mitchell & Seymour 2023). Both formal enterprises and informal community structures thus require sustained investment and coordination to avoid cascading failure across social, economic, and cultural domains.

3.3.4 Socioeconomic trends that may exacerbate the risk

A key socioeconomic trend exacerbating Māori exposure to economic losses in primary industries is the structural misalignment between Māori collective development models and the prevailing financial and regulatory systems (Rout & Whitehead 2023; Rout et al. 2023). While this mismatch has been noted across adaptation and resilience policy settings, its effects are especially pronounced in primary industries where financial support is often conditional on risk disclosure and return metrics that exclude tikanga-based priorities. This structural mismatch reflects a broader issue: national climate and economic policy settings often treat resilience as a technical or fiscal concern, rather than one grounded in relational obligations to land, whakapapa, and collective well-being (Tapsell 2022). As a result, informal Māori economies, such as customary food production, community-based ecological restoration, and rangatahi-led initiatives, are often largely invisible in funding frameworks and overlooked in adaptation planning. This disconnect is compounded by limited digital infrastructure, constrained access to environmental data, and under-resourced regional planning support, which reduces the ability of Māori collectives to engage in risk disclosure, climate reporting, or adaptive investment (White et al. 2021; Envirostrat Limited 2024).

In many areas, especially where land is multiply owned, the lack of spatial data sovereignty and access to real-time hazard information limits proactive risk planning. The need for tikanga-based data platforms is increasingly recognised by Māori-led initiatives (Sharma et al. 2024). Māori landholdings are often concentrated in environmentally vulnerable regions, where infrastructure degradation and climate impacts affect productivity (Te Rūnanga o Te Rarawa 2021; Mika & MacDonald 2024). These vulnerabilities are compounded by the persistence of colonially embedded land tenure systems, which constrain the legal and administrative flexibility needed for Māori collectives to qualify for adaptation funding or to pivot into climate-resilient land use models (Bargh & Tapsell 2021; Kingi et al. 2023). For informal enterprises, such as mahinga kai collectives or community maramataka-based harvest initiatives, rigid tenure arrangements can prevent innovation or limit access to shared infrastructure and capital.

© New Zealand Institute for Bioeconomy Science Limited (2026)

These trends, combined with gaps in targeted support, increase the likelihood that Māori enterprises will absorb disruption costs without adequate recovery tools, limiting long-term economic resilience. Johnson, Fisher and Parsons (2023) note that for wāhine Māori leading land-based enterprises, persistent underfunding, market access limitations, and planning exclusion converge to heighten their precarious status, particularly when climate events disrupt community-scale food and aquaculture initiatives.

3.3.5 Climate thresholds and tipping points

Several economic, environmental, and institutional thresholds could influence the severity of climate impacts on Māori primary industries. Biophysical thresholds may be crossed when climate hazards such as drought, storm damage, or ocean warming exceed the tolerances of productive systems, including pasture, crops, or aquaculture species (Howarth & Major 2023; Percy et al. 2024). For instance, sea temperature increases beyond critical ranges may reduce shellfish survival or growth, while sedimentation or biosecurity breaches may damage mussel farms and hatcheries (Skelton et al. 2023). Additional thresholds are emerging in the context of invasive species and forest pathogens, such as those causing myrtle rust and kauri dieback disease. When exacerbated by warmer and wetter conditions, these biosecurity threats risk widespread disruption to significant forest ecosystems. Ecological restoration becomes increasingly complex, or infeasible once critical canopy cover or seedbank diversity is lost (Lambert & Mark-Shadbolt 2021; Wood et al. 2024). These ecological tipping points affect both commercial Māori enterprises (e.g., forestry and aquaculture) and informal kai systems that rely on access to taonga species.

Institutional and policy thresholds may also be reached when insurance becomes unavailable or unaffordable, when compliance costs exceed the capacity of small-scale Māori enterprises, or when climate finance systems do not accommodate collective ownership and intergenerational planning (Rout et al. 2023; Mika & MacDonald 2024). This risk applies to formal enterprises struggling with regulatory complexity, as well as to informal community-based economies that lack legal personhood or recognition within funding frameworks. These thresholds may be exceeded earlier under high emissions scenarios or in regions where infrastructure degradation is already advanced, such as in Te Tairāwhiti (East Coast) (Ministerial Inquiry into Land Use 2023) and Te Matau-a-Maui (Hawke’s Bay) (Envirostrat Limited, 2024).

Governance thresholds are also becoming apparent, particularly where existing emergency or adaptation systems fail to uphold Te Tiriti obligations or support tikanga-led responses. As Tapsell (2022) and Erueti et al. (2023) argued, the exclusion of Māori from structural decision-making in climate governance may erode the legitimacy and effectiveness of national climate adaptation policy over time (Tapsell 2022; Erueti et al. 2023). Johnson, Fisher and Parsons (2023) cautioned that community-scale tipping points may be triggered when whānau-based kai systems fail repeatedly, particularly where restoration funding and regulatory support are inaccessible. In such instances, it is not only economic production that declines, but also the relational, cultural, and emotional systems maintained through tikanga and informal enterprise. Social, economic, and emotional losses accumulate across generations, making recovery increasingly difficult.

A tipping point may occur when repeated losses lead to the withdrawal of Māori enterprises from primary sectors, particularly those operating with low margins or firm commitments to vulnerable species or places. Suppose successive events erode production viability, such as repeated flooding, market inaccessibility, or regulatory barriers. In that case, whānau-based enterprises may lose the capacity to recover or reinvest, reducing Māori economic autonomy and intergenerational development pathways (Ministerial Inquiry into Land Use 2023; Rout & Whitehead 2023). This applies equally to informal economies: when repeated disruption undermines mahinga kai or

© New Zealand Institute for Bioeconomy Science Limited (2026)

whānau-led restoration efforts, the resulting loss in place-based identity, food security, and cultural practice can lead to cascading disconnection from the whenua. Such a scenario could also trigger a loss of rangatahi engagement with climate-vulnerable primary sectors, further weakening resilience.

This concern is reinforced in recent analyses of mātauranga Māori and employment instability, where disconnection from land-based practices is linked to a long-term decline in intergenerational knowledge transfer and economic agency (Apiti et al. 2023). Suppose both formal and informal Māori enterprises collapse under pressure. In that case, the cumulative effects may include reduced opportunities for rangatahi employment, weakened papakāinga resilience, and diminished investment in ecological restoration or food resilience initiatives. The breakdown of these enterprises may also reduce opportunities for rangatahi employment, undermine papakāinga resilience, and weaken investment in ecological restoration or food resilience initiatives (Paul & Ratana 2022; Lück et al. 2024). While adaptation is possible, sustained underinvestment in infrastructure and a lack of inclusive finance models may shift the risk from episodic to systemic under higher warming pathways. Ensuring that both regulated Māori businesses and tikanga-based economies have equitable access to infrastructure and financial tools is critical to avoiding these tipping points.

3.3.6 Possible interactions with climate mitigation actions

Climate mitigation efforts, particularly those targeting agricultural emissions, land-use change, and forestry expansion, are likely to have significant implications for Māori involvement in primary industries (Kingi et al. 2023). On one hand, Māori landowners and enterprises may benefit from opportunities associated with emissions reduction, such as carbon farming, regenerative agriculture, or investment in low-emissions horticulture and aquaculture (Mika & MacDonald 2024). If supported by Te Tiriti-aligned finance mechanisms, such pathways could reduce long-term risk exposure and diversify economic activity. These opportunities primarily target formal Māori enterprises operating in regulated primary sectors. Nevertheless, there is also potential to support informal systems where whānau and hapū are engaging in ecosystem restoration, native planting, and customary fisheries management for intergenerational well-being.

However, mitigation policies that rely heavily on afforestation (particularly exotic carbon forestry) or rigid emissions targets for pastoral farming may displace Māori food production and limit tikanga-based land-use practices, especially on marginal or erosion-prone lands (Ministerial Inquiry into Land Use 2023; Rout & Whitehead 2023). This risk is heightened by the Emissions Trading Scheme's (ETS) structural bias toward exotic species, which disadvantages Māori landowners who seek to regenerate native forest ecosystems for both tikanga-based and climate outcomes. As noted by Buckley et al. (2023), policy and market mechanisms have failed to create equitable incentives for native planting despite Māori preferences for these options on whenua tuku iho (inherited/ancestral land). Informal Māori economies, particularly those focused on local food systems and native forest-based healing, rongoā, or cultural practices, are particularly vulnerable to land-use pressures created by carbon forestry and mitigation-linked afforestation schemes.

In some cases, mitigation requirements may impose compliance burdens that are misaligned with the governance and capital structures of Māori collectives, restricting access to emissions reduction incentives or forcing trade-offs between economic viability and tikanga-based priorities (Kingi et al. 2023; Mitchell & Seymour,2023; Rout et al. 2023). These burdens are especially acute for informal economies and community-led initiatives that often lack the administrative and financial infrastructure necessary to participate in emissions markets, despite these initiatives delivering tangible environmental and cultural benefits. Short-term emissions targets may also inadvertently

© New Zealand Institute for Bioeconomy Science Limited (2026)

penalise long-term, intergenerational land use strategies prioritising slow-growing native species or collective food production. These tensions have been documented in critiques of our national Emissions Reduction Plan and the National Adaptation Plan (Tapsell, 2022).

Climate change could also make mitigation harder to achieve by reducing yields or productivity in sectors like aquaculture and forestry, constraining the emissions efficiency of Māori enterprises (Howarth & Major 2023; Skelton et al. 2023). For example, storm-driven sedimentation and marine heatwaves are already affecting the viability of low-emissions aquaculture models grounded in mātauranga Māori and ecosystem regeneration (Skelton et al. 2023). Without targeted adaptation support, these innovations may struggle to scale or endure. Moreover, informal innovation, such as maramataka-aligned planting or whānau-based restoration projects, may be left unsupported and uncounted in mitigation accounting frameworks, despite their ecological and cultural significance.

Conversely, Māori-led innovation in sustainable fisheries, eco-tourism, or blue carbon restoration could offer mitigation pathways aligning with tikanga and long-term whānau well-being – if supported by fit-for-purpose investment frameworks. Projects integrating maramataka-based planning, seaweed restoration, or mātauranga-informed biodiversity monitoring demonstrate strong potential for dual adaptation and mitigation benefits (Lambert & Mark-Shadbolt 2021; Apiti et al. 2023). These projects often span both formal enterprises and informal collectives yet remain undercapitalised and disconnected from emissions accounting and mainstream climate finance tools**,** and from mitigation finance frameworks.

In addition to these pressures, Māori land, particularly erosion-prone or marginal land, is increasingly being targeted for ecosystem restoration programmes aimed at flood attenuation, carbon sequestration, and land stabilisation. While these initiatives offer important environmental benefits, they often necessitate a transition from more economically productive land uses to less profitable restoration regimes. This shift disproportionately impacts Māori, who are expected to bear the cost of delivering public environmental goods without receiving corresponding compensation or equitable benefit sharing. As Rout and Whitehead (2023) noted, this dynamic reinforces historical disadvantage by limiting the capacity of Māori to fully use their whenua in alignment with both economic aspirations and tikanga. Without changes to how ecosystem services are valued and compensated, these restoration pressures may deepen existing structural inequities under the guise of climate mitigation.

Ultimately, the alignment between mitigation and Māori economic resilience will depend on the degree of structural flexibility, recognition of tikanga, and access to capital within emissions policy and climate finance systems. Ensuring that both market-facing Māori enterprises and non-market, tikanga-based economies are supported is essential for just and effective climate mitigation outcomes.

3.3.7 Data gaps

Notable data gaps exist in understanding how climate impacts specifically affect Māori-owned or Māori-operated primary industries. While general projections for agriculture, aquaculture, and forestry are well-established, disaggregated data for Māori enterprises is limited, particularly regarding exposure levels by region, land class, or asset type (Rout et al. 2023; Mika & MacDonald 2024). Existing data sets typically focus on formal enterprises, overlooking informal Māori economies such as mahinga kai networks, whānau-based nurseries, or customary fisheries, which are equally vulnerable to climate impacts. This lack of granularity inhibits effective monitoring of Māori-specific vulnerabilities and obscures where targeted investment or support might yield the most effective resilience outcomes (Sharma et al. 2024). Te Rūnanga o Te Rarawa (2021) found

© New Zealand Institute for Bioeconomy Science Limited (2026)

that regional data sets often exclude papakāinga, hapū nurseries, and small-scale aquaculture, limiting local recovery planning and precluding access to resilience funding.

Sensitivity is also under-explored: few national studies assess how Māori governance models, asset portfolios, or economic structures mediate vulnerability to climate events. Research by Tapsell (2022) and Erueti et al. (2023) has highlighted that the absence of kaupapa Māori –aligned indicators in national climate data sets makes it difficult to measure the effectiveness of adaptation or mitigation initiatives in terms that reflect Māori values or goals, such as whakapapa continuity, collective well-being, or whenua stewardship. Furthermore, distinctions between formal commercial enterprises and tikanga-based, non-market systems are rarely captured, masking the different ways vulnerability is experienced and managed in each context.

Adaptive capacity remains one of the weakest areas of documentation, with sparse information on Māori access to insurance, climate finance, or emissions-related transition tools, especially for smaller whānau collectives or rural enterprises. There is even less visibility for informal adaptation efforts, such as marae-based food production, community restoration projects, or rangatahi-led initiatives, which often lack legal or financial infrastructure and are excluded from mainstream reporting.

Localised mātauranga about climatic rhythms, seasonal indicators, or native species behaviours is not systematically supported by state institutions, meaning it is underused in formal climate risk modelling (Lambert & Mark-Shadbolt 2021; Apiti et al. 2023). The lack of investment in Māori data infrastructure further exacerbates this situation. Sharma et al. (2024) identified the need for cloud-based, trusted geospatial platforms that enable Indigenous data sovereignty, allowing Māori to control, store, and verify their biodiversity and climate data without compromising site security or tikanga-based protocols. The absence of such systems limits Māori capacity to engage with planning processes on equal terms or to meet compliance standards for resilience funding. Additionally, economic reporting frameworks rarely capture the relational and intergenerational dimensions of Māori development, meaning that economic resilience is likely undervalued in official assessments. Informal economies, remain structurally invisible in economic data, despite their critical role in local resilience. As Tapsell (2022) argued, metrics for economic success in mainstream policy rely on individualised, short-term indicators (e.g., GDP, business margins), which can misrepresent the actual state of collective Māori economic resilience or obscure the relational costs of ecological degradation.

Future assessments should invest in disaggregated data collection that distinguishes between values-based, customary, and commercial Māori enterprises. Without detailed sector-specific exposure modelling, including large-scale sheep/beef, dairy, and plantation forestry, the national climate risk picture remains incomplete. It may underestimate not only the economic vulnerability of formal Māori businesses but also the vulnerabilities experienced by informal Māori economies in climate-sensitive sectors.

3.3.8 Confidence level

The overall strength of the evidence base is moderate, with good coverage of general climate-economic trends but limited specificity for Māori contexts. Agreement across sources is strong that Māori primary industries are at high risk due to their concentration in land-based and marine sectors, and that institutional barriers constrain adaptive responses (Rout & Whitehead 2023; Envirostrat Limited 2024). However, the quality of evidence varies, while qualitative insights are strong (e.g., case studies, inquiry submissions). Comprehensive, sector-wide Māori economic data about changing climate conditions remains scarce. There is minimal visibility for informal Māori economies, such as whānau-based food systems, marae-driven aquaculture, or collective

© New Zealand Institute for Bioeconomy Science Limited (2026)

restoration projects, which are not consistently included in national economic or climate resilience assessments. Confidence in exposure patterns is medium to high; however, confidence in sensitivity and adaptive capacity is lower due to the lack of sufficient national-level metrics and monitoring.

As Sharma et al. (2024) identified, current data architectures do not enable the full participation of Māori in spatially explicit climate modelling or risk disclosure frameworks, leading to a significant underrepresentation of Māori enterprise vulnerability in official data sets. Informal economies are almost entirely excluded from these systems, despite playing a critical role in regional food security, cultural continuity, and intergenerational resilience. Tapsell (2022) and Erueti et al. (2023) emphasised that existing policy assessments often overlook Māori definitions of well-being, risk, and resilience. This results in inflated confidence levels in some policy domains due to misalignment between Māori and mainstream governance paradigms. Risk assessments that rely solely on conventional enterprise metrics may thus miss systemic vulnerabilities within tikanga-based or relational Māori economies. The risk is likely to be more consequential than current data systems suggest, especially where cascading effects across economic, social, and governance systems are poorly understood and poorly captured.

3.3.9 Risk severity summary

Table 9 presents the risk severity criteria for economic losses in Māori primary industries across four levels of risk, from minor to extreme. It draws on published literature to assess how climate impacts, land use constraints, and structural barriers to investment may undermine Māori economic resilience over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 9: Economic losses in Māori primary industries risk severity criteria

Attributes	Minor	Moderate	Major	Extreme
Overarching	• Localised income or production losses affecting single enterprises. • Impacts recoverable with available insurance or contingency funding. • Tikanga-based production practices largely intact.	• Regional disruption to Māori-owned enterprises (e.g. aquaculture, forestry, farming). • Informal economies face temporary hardship. • Customary food sharing and mātauranga practices constrained but recoverable.	• Significant, multi-sectoral disruption across Māori primary industries • Both formal and informal economies destabilised. • Tikanga-aligned governance, wāhine-led enterprise, and food security under pressure.	• System-wide failure of Māori economic resilience across primary sectors. • Collapse of informal kai systems and loss of enterprise viability. • Withdrawal from whenua-based economic enterprise.
Extent, duration and frequency of likely impacts	• Climate disruptions (e.g. droughts, floods) cause short-term impacts. • Income recovery is swift and food systems intact.	• Recurring weather events and biosecurity threats affect annual production cycles. • Extended disruption to mahinga kai, harvest, or seasonal enterprise planning.	• Persistent climate events disrupt maramataka-aligned activity and commercial viability. • Long-term impacts on whānau employment and economic autonomy.	• Repeated climate shocks lead to permanent withdrawal from taonga-based informal activities. • Irregular seasonal patterns weaken informal economic activities. • Economic collapse of formal economic activities in highly exposed regions.
Ability to recover from likely impacts	• Whānau enterprises and cooperatives recover using internal support or targeted grants. • Marae-based initiatives resume quickly.	• Partial recovery reliant on external finance or regulatory reform. • Access to insurance, data, and technical services inconsistent. • Informal systems recover slowly.	• Recovery requires significant policy realignment and co-governance in climate finance. • Informal economies lack visibility or access to tools. • Investment pathways fragmented or inaccessible.	• Recovery infeasible under current climate and economic policy frameworks. • Constitutional and financial transformation required to restore equity. • Tikanga-based enterprise systems face generational loss.
Likely equity impacts	• Limited equity concerns; resilience tools accessible to most Māori enterprises. • Informal economies continue to operate.	• Structural barriers limit recovery for some Māori collectives. • Digital, financial, and infrastructure inequalities increase regional disparities.	• Māori disproportionately bear climate-induced costs. • Informal economies (esp. wāhine-led or rangatahi-run) excluded from recovery frameworks. • Intergenerational economic inequities deepen.	• Systemic exclusion entrenched. • Māori economic models misaligned with state climate finance and policy. • Community disconnection from whenua and collapse of collective resilience.
Likely impacts on te ao Māori	• Economic frameworks overlook Māori models but do not obstruct them. • Limited disruption to tikanga-led activity.	• Tikanga and maramataka considered inconsistently in regulatory settings. • Kaupapa Māori enterprises under-recognised in planning systems.	• Climate and market systems displace tikanga-aligned practices. • Loss of mana whenua and economic control. • Disruption to mātauranga-informed economic activities.	• Tikanga, whakapapa-based governance, and informal economies collapse. • Māori land use determined by external agencies. • Economic sovereignty lost.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 10) elaborates on the projected severity of increased economic losses for Māori under different warming scenarios, drawing on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. We utilised the Commission's scoring template for compiling our risk severity scores (see Appendix 3). By mid-century (1.5°C–2°C warming), increased weather extremes will likely disrupt production and create financial stress, particularly for whānau-scale and values-based enterprises. This includes mara kai, community food sovereignty initiatives, and kaitiaki-led marine or forest restoration projects, which already operate with limited resources and capacity. However, the severity and nature of impacts will vary by industry and region, with cascading effects in areas where infrastructure damage, regulatory burdens, or ecological decline overlap. By the end of the century (2.5°C–3.5°C warming), repeated shocks could lead to long-term losses, business closures, and reduced whānau economic resilience. The severity of the risk increases significantly under high-emissions scenarios, where physical damage and institutional gaps become more challenging to manage.

Without substantive changes to climate governance, including access to finance, infrastructural equity, and the embedding of tikanga-based planning, Māori economic exposure to climate change is likely to increase, entrenching systemic vulnerabilities (Bargh & Tapsell 2021; Tapsell, 2022). Policies must explicitly support both formal Māori enterprises and informal, tikanga-driven economies, or else risk reproducing inequities through well-intentioned but structurally misaligned adaptation and mitigation strategies. Regionally specific strategies that recognise different climatic pressures and sectoral needs will be essential to reduce inequity and avoid compounding economic loss. Without changes to finance, infrastructure, and governance settings, Māori economic exposure to climate change is likely to worsen over time.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 10: Risk severity scores under different climate scenarios for economic losses in Māori primary industries

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Economic losses in Māori primary industries	Māori enterprises, especially whānau-scale, marae-based, or kaupapa Māori ventures, face systemic barriers in finance, infrastructure, and climate planning. Some sectors are already experiencing localised climate-related stress, but adaptive capacity remains where tikanga-based practices are supported.	Climate extremes begin to disrupt operations more frequently, particularly in farming, aquaculture, forestry, and fisheries. Values-based enterprises with limited capital face growing financial stress. Regional inequities worsen where infrastructure and regulatory burdens intersect with ecological degradation.	Repeated shocks, ongoing ecological disruption, and cascading infrastructure impacts erode Māori economic resilience. Losses become harder to recover without policy reform. Whānau-scale and tikanga-aligned initiatives struggle to remain viable under mounting climate and regulatory pressure.	Sustained climate stress, coupled with continued underinvestment and exclusion from finance and infrastructure planning, results in systemic economic loss. Business closures, intergenerational asset erosion, and institutional misalignment entrench long-term vulnerability. Without transformative change, Māori economic systems become severely undermined.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.4 Disruption to tikanga and hapū/iwi identity

This section examines how climate change-induced displacement, coastal erosion, and managed retreat risk severing Māori connections to whenua, threatening identity, sustained practice of tikanga, and intergenerational well-being. Table 11 outlines the risks of disruption to tikanga and hapū/iwi identity for Māori under climate change, particularly from sea-level rise, coastal erosion, and managed retreat. It emphasises how disconnection from whenua, marae, and taonga sites erodes intergenerational knowledge transmission, undermining Māori identity, well-being, and whakapapa-based relationships with place.

Table 11: Summary table for the climate risk of disruption to tikanga and hapū/iwi identity

Risk overview	Climate change-driven sea-level rise, erosion, and managed retreat threaten Māori place-based identities, undermining whakapapa, tikanga, and mātauranga Māori. Disconnection is particularly acute for wāhine Māori, who hold key intergenerational knowledge and tikanga-based roles.
Exposure (current, 2050, 2090)	Current exposure is high in coastal and riverine areas, increasing with sea-level rise and policy misalignment. By 2090, managed retreat may further erode identity unless Te Tiriti-consistent, Māori-led adaptation frameworks are implemented.
Sensitivity and adaptive capacity	Sensitivity is high due to whakapapa ties to land and wāhine-led relational roles. Adaptive capacity exists along with maramataka-based planning, but is constrained by structural gaps in law, funding, and governance.
Compounding and cascading factors	Displacement affects wāhine, tikanga-based mentoring, kaitiakitanga, and local governance. Without tikanga-led adaptation, dislocation may cascade into knowledge loss, identity fragmentation, and weakened social, economic and ecological resilience.
Socioeconomic trends	Urbanisation, disconnected planning, and underinvestment in kaupapa Māori housing exacerbate risks. Wāhine Māori face intensified pressures from care work, community leadership, and a precarious labour situation under climate stress.
Climate thresholds and tipping points	Thresholds may be crossed when sites become uninhabitable or uninsurable, or when adaptation excludes Māori leadership. Tipping points include the loss of sustained practice of tikanga, the abandonment of marae, and a decline in intergenerational knowledge transfer.
Interactions with mitigation actions	Mitigation may either support or threaten Māori identity. Risks arise from poorly designed afforestation or carbon schemes. Opportunities exist in Māori-led low-emissions housing and marine restoration, provided they are supported and values-aligned.
Data gaps	Lack of data on mātauranga-informed indicators, site-specific impacts, and Māori adaptive strategies limits planning. The absence of Māori data sovereignty and relational metrics undermines the visibility of mātauranga Māori-informed loss and well-being risks.
Confidence level	Moderate confidence. Strong qualitative evidence exists, but quantitative data and national monitoring of mātauranga-informed impacts are limited. The roles and experiences of wāhine Māori are especially underrepresented in planning systems.

Sea-level rise, coastal erosion, and managed retreat present existential threats to Māori communities living on or near their ancestral lands. These challenges disrupt the physical landscape and sever whakapapa-based relationships with place, undermining the transmission of mātauranga Māori. The risks extend to the maintenance of reo and tikanga, exacerbating intergenerational trauma rooted in historical land dispossession. This is particularly acute for wāhine Māori, whose identities, responsibilities, and tikanga-based roles are often place-anchored and embodied through care work and intergenerational knowledge transmission (Johnson et al. 2022; Johnson, Parsons & Fisher 2023; Johnson, Fisher & Parsons 2024).

As highlighted by Masters-Awatere, Young, and Graham (2022), the well-being of Māori is affected by displacement, which leads to identity shocks and intergenerational anxiety, mainly when land degradation and infrastructure damage occur. Similarly, Stephenson, Kawharu et al. (2023)

© New Zealand Institute for Bioeconomy Science Limited (2026)

pointed to the threats faced by urupā, marae, and kāinga due to erosion and rising sea levels, often exacerbated by a lack of meaningful partnership with the Crown in iwi-led responses.

Erosion and marine degradation disrupt whakapapa-based connections to place, particularly when governance fails to prioritise Māori perspectives, as noted by Envirostrat Limited (2024). Berghan (2021), along with Paul and Ratana (2022), further emphasised the ongoing impacts of urbanisation and land alienation, which have fragmented traditional communities and severed ties to ancestral lands. These effects are compounded by environmental threats that could lead to further dislocation. Projects in Te Tai Tokerau and the Kaipara region have documented how dislocation undermines wāhine-led tikanga, particularly where neoliberal adaptation frameworks marginalise Māori-led responses and deepen settler colonial logics of land use (Johnson et al. 2022; Johnson, Fisher & Parsons 2024). In Te Tau Ihu (top of the South Island), for instance, Our Land and Water NSC researchers have documented chronic degradation of freshwater and coastal systems, leading to a decline in hapū/iwi well-being, and the collapse of customary fishing rights, all underpinned by successive failures to uphold Te Tiriti-based protections (Our Land and Water 2021). Similar concerns were raised by Lambert and Mark-Shadbolt (2021), who documented how the degradation of taonga species under biosecurity and climate stress undermines kaitiakitanga and intergenerational transmission of mātauranga Māori.

For Māori, kāinga and marae hold significant importance beyond their physical presence; they serve as essential locations for passing down whakapapa, reo, and tikanga. When people are displaced, these practices are interrupted, and ties weaken. If housing and relocation policy is not led by Māori authority, the disruption lasts, limiting rangatahi access to language, tikanga, and support networks (Ratana 2023). The Project Kāinga initiative (is a five-year research programme working with marae communities to plan and test tikanga-based responses to climate change) illustrates how whakapapa-based methodologies can foster resilience and the regeneration of kāinga in a tikanga-based manner. Although it is not explicitly focused on managed retreat, research (e.g. Kawharu 2023) has emphasised the necessity of Te Tiriti-consistent, kin-based approaches in planning and development to prevent the repetition of exclusionary patterns. Erueti et al. (2023) similarly argued that current relocation and adaptation frameworks frequently treat Māori as stakeholders rather than partners, compounding hapū/iwi well-being risks through exclusion in decision-making processes. Without a Te Tiriti-consistent approach to managed retreat, communities remain at risk of repeating colonial patterns of dispossession disguised as climate adaptation.

Accelerated climate impacts on marine ecosystems undermine the ecological baselines on which mātauranga Māori depends. When taonga species or habitats disappear, so too do the tohu (indicators) used to guide harvests and maintain ecosystem balance. Projects like Taura Kuku and Kohunga Kūtai that both looked at biodegradable mussel spat lines, show how Māori-led innovation is regenerating traditional knowledge in response to plastic pollution and species decline, but these efforts are vulnerable to environmental volatility and underfunding (Paul-Burke et al. 2022; Skelton et al. 2023). Other community-based responses, such as the Tai-o-Rongo Research Collective's maramataka framework at Awhi Farms, highlight the potential of tūpuna knowledge to guide land and ocean-based resilience strategies. However, these innovations remain precariously under-resourced and lack institutional support for scaling (Tai-o-Rongo Research Collective, 2024). Tapsell (2022) also noted the limited incorporation of mātauranga Māori into climate policy, which can restrict the systemic visibility and support for such initiatives. Revitalising knowledge systems in aquaculture, restoration, and maramataka practice is increasingly urgent as marine climate shifts accelerate.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.4.1 Exposure – current, 2050 and 2090

Hapū/iwi and Māori identity is closely tied to place, particularly ancestral lands, waterways, and coastal ecosystems. As climate change disrupts these geographies, there is growing concern about the potential disruption to tikanga and hapū/iwi identity. The exposure arises not only from environmental stressors such as sea-level rise and erosion, but also from the lack of tikanga-based pathways for adaptation, particularly for relocation or managed retreat (Masters-Awatere, Young, & Graham 2022; Stephenson, Kawharu et al. 2023). Wāhine Māori face additional exposure due to their gendered roles as caregivers, practitioners of tikanga, and healers, roles that are particularly affected by degraded infrastructure, unsafe water access, and relocation processes that overlook Māori planning principles (Johnson, Fisher & Parsons 2024).

Māori communities living near coasts and river mouths are experiencing increased risk of flooding and erosion. These hazards affect kāinga, marae, and urupā, sites critical for whakapapa transmission, tikanga, and collective governance. In some instances, communities have already faced the prospect of relocating structures or responding to the erosion of sacred sites (Pohatu & Walker 2021; Bailey-Winiata et al. 2024). While not universal, these experiences indicate a growing exposure to place-based disconnection. Tapsell (2022) highlighted that current legal frameworks around retreat fail to acknowledge these sites' collective and spiritual dimensions, intensifying risk for significant sites. As noted by Johnson, Parsons, and Fisher (2023), climate-related loss and damage for wāhine Māori often manifests in severed identity pathways, where loss of access to whenua is compounded by a lack of tikanga-based spaces to transmit whakapapa and enact responsibilities to whenua and whānau.

Projections for mid-century (c. 2050, with c. 1.5°C –2°C warming) suggest continued degradation of ecosystems that support tikanga and identity. Declines in species and habitats associated with mahinga kai and rongoā may erode the ecological foundations of mātauranga Māori and seasonal rhythms (Paul-Burke et al. 2022; Tai-o-Rongo Research Collective 2024). These losses would affect physical access to kai, rongoā, pūrakau, and intergenerational knowledge embedded in these practices (Skelton et al. 2023; Mahuta & van Schravendijk-Goodman 2024). Lambert and Mark-Shadbolt (2021) noted that biosecurity threats linked to climate change are accelerating disruption to tikanga, particularly where customary access is restricted due to species decline or habitat instability.

By the end of the century (i.e. in about 2090), with warming reaching 2°C–3.5°C, the cumulative effect of displacement, infrastructure damage, and ecosystem change may further challenge the sustained practice of tikanga. However, the extent of identity loss will depend on the availability of mana-enhancing adaptation frameworks and the degree to which Māori are supported to lead their climate responses (Ratana 2023; Bailey-Winiata et al. 2024). Currently, managed retreat frameworks are not well-aligned with Māori land relationships, which are collective, relational, and rooted in whakapapa rather than individual titles (Rout & Walker 2021; Whitehead & Walker 2021). Erueti et al. (2023) noted that the lack of structural roles for hapū and iwi in planning processes limits the ability to uphold ahi kā and implement tikanga-based relocation strategies.

There is a degree of uncertainty in projecting disruption to tikanga, as impacts vary by rohe and depend heavily on local leadership, whānau cohesion, and support structures. Nonetheless, repeated disruptions to access, land use, and ceremony can contribute to longer-term erosion of language, values, and identity, mainly where relocation or adaptation is not governed by Māori priorities (Cram 2021; Kawharu 2023). Yletyinen et al. (2022) further suggested that even seemingly minor changes in environmental access can cascade through Māori systems, rapidly affecting identity expression and knowledge transfer.

© New Zealand Institute for Bioeconomy Science Limited (2026)

While exposure increases, Māori-led projects such as Project Kāinga and kaupapa Māori housing initiatives provide examples of tikanga-based responses that maintain connections to place and identity. Support for these approaches may reduce future exposure and support intergenerational well-being (Berghan 2021; Andersen 2024). Additional efforts, such as maramataka-based planning and the resurgence of place-based learning hubs, as identified in Apiti et al. (2023), further illustrate how tikanga can guide adaptation.

3.4.2 Sensitivity and adaptive capacity

Māori are particularly sensitive to the risk of disruption to tikanga and hapū/iwi identity due to the foundational role that place-based relationships play in Māori identity and well-being. Whenua is not merely a site of residence or economic activity but also a living ancestor and central node in whakapapa relationships. As such, the prospect of losing access to ancestral lands, whether through coastal erosion, flooding, or managed retreat, poses significant risks to the transmission of tikanga, te reo, and mātauranga Māori (Masters-Awatere, Young, Howard et al. 2022; Stephenson, Kawharu et al. 2023). This sensitivity is especially pronounced among wāhine Māori, whose responsibilities to mokopuna, marae, and whenua create layered vulnerabilities, while also sustaining resilience through care-based leadership and tikanga and mātauranga revival (Johnson, Parsons & Fisher 2023).

This sensitivity is compounded in communities where marae, urupā, and papakāinga are in high-risk zones. Their degradation or potential relocation may sever intergenerational ties to land and undermine the continuity of customary practices and community governance. Research highlights that hapū/iwi well-being following displacement can manifest as identity disruption, intergenerational anxiety, and diminished social cohesion (Bailey-Winiata et al. 2024; Ratana 2023). These effects are especially pronounced where relocation is imposed, or decision-making authority is held externally. Erueti et al. (2023) emphasise that procedural exclusion, where Māori are consulted but not co-decision-makers, undermines whānau and hapū capacity to define their adaptation strategies, thus heightening vulnerability. As noted by Johnson, Fisher, and Parsons (2023), adaptation initiatives that emphasise infrastructure or economic development without addressing intersecting forms of marginalisation can increase the load on wāhine Māori. These women often become the “shock absorbers” of maladaptive policies, working longer hours in hazardous conditions to sustain both income and intergenerational stability.

Māori adaptive capacity in this area is reasonably strong but highly contingent on legal and institutional settings. Many communities have developed whakapapa-based models for housing, governance, and land stewardship that support resilience and continuity in the face of change. Initiatives such as Project Kāinga and papakāinga housing frameworks illustrate how relocation and housing design can be undertaken to enhance, rather than erode, hapū/iwi identity (Berghan 2021; Andersen, 2024). Mātauranga Māori also provides principles, such as ahi kā, kaitiakitanga, and whanaungatanga, that can guide tikanga-based responses to land use pressures. This is particularly true where wāhine Māori lead resurgence efforts that weave social, economic, spiritual, and environmental roles together to maintain whakapapa (Johnson, Parsons & Fisher 2023).

However, these capacities are often constrained by the lack of Te Tiriti-consistent frameworks for managed retreat or relocation. Current legal and planning tools primarily focus on private property models and individual compensation that is unsuited to collective tenure or whakapapa-based connections to land (Rout & Walker 2021; Whitehead & Walker 2021). This disconnect can prevent Māori from shaping their relocation processes or securing support for tikanga-based reconnection strategies.

© New Zealand Institute for Bioeconomy Science Limited (2026)

There is moderate uncertainty about the long-term effects of disrupting tikanga. While climate projections can estimate physical risk to land, the social consequences of relocation are highly variable and influenced by community cohesion, resource access, and governance inclusion. Furthermore, the scale and timing of managed retreat remain undefined for many areas, adding complexity to planning and decision-making. Tapsell (2022) argued that without structural integration of tikanga into governance, Māori adaptive capacity would remain institutionally constrained, regardless of whānau capability. This integration includes the need for adaptation funding frameworks that recognise collective stewardship rather than solely economic productivity. Johnson, Fisher and Parsons (2023) reinforced this point by illustrating how exclusion from water governance in Te Tai Tokerau intensified existing burdens for Māori women and failed to protect the social, economic and ecological values tied to water and place.

3.4.3 Compounding and cascading factors

Disruption of tikanga and hapū/iwi identity may arise from the intersection of multiple climate risks, particularly where environmental change threatens longstanding relationships with ancestral lands, rivers, and coastal sites. Hazards such as flooding, coastal erosion, and sea-level rise interact with legal and planning frameworks that are not always equipped to support Māori governance or relational land tenure systems (Rout & Walker 2021; Stephenson, Kawharu et al. 2023). In this context, managed retreat, if not implemented in Te Tiriti-consistent ways and tikanga-informed, can become a source of risk.

Where retreat is approached through market-based or cadastral frameworks, Māori communities face potential loss of ahi kā, spiritual connection, and mana whakahaere over whenua (Whitehead & Walker 2021; Pirini 2024). This can result in further marginalisation, especially where hapū and iwi are excluded from defining the conditions and processes of relocation (Ministerial Inquiry into Land Use 2023; Bailey-Winiata et al. 2024). Erueti et al. (2023) stressed that leaving whānau out of managed retreat planning can harm their ability to govern whenua collectively and disrupt their te ao Māori decision-making processes.

Wāhine Māori are disproportionately affected by these risk intersections, especially where adaptation pathways fail to reflect their embedded roles in caregiving, tikanga-based resource planning, and intergenerational knowledge transfer (Johnson, Parsons & Fisher 2023). These responsibilities are often unrecognised in formal adaptation planning, increasing the risk of losing tikanga-based practices when dislocation occurs without wāhine leadership and mātauranga-informed strategies. As Johnson, Fisher, and Parsons (2023) documented, the physical and emotional wear of working in precarious labour linked to maladaptive infrastructure, such as intensified horticulture tied to water storage, reduces well-being and the time available for practising tikanga and relational healing.

Disruption to tikanga can also contribute to cascading risks in other domains. Disrupted connections to place may weaken the practice of kaitiakitanga, reduce engagement with maramataka, and limit the transmission of site-specific mātauranga Māori (Pohatu & Walker 2021; Tai-o-Rongo Research Collective 2024). This, in turn, may affect ecological restoration efforts, local food systems, and intergenerational well-being. Lambert and Mark-Shadbolt (2021) and Tapsell (2022) have highlighted the fact that disruption to tikanga is intensified when Indigenous knowledge systems are siloed or tokenised in environmental governance, limiting their potential to guide holistic adaptation strategies. As marae and kāinga often serve as hubs for decision making, ceremony, and collective care, their degradation or relocation without community control may affect governance cohesion and identity formation (Kawharu 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

While Māori collectives have advanced adaptive housing and planning frameworks rooted in whakapapa and whānau responsibilities (Berghan 2021; Andersen 2024), these can be undermined when adaptation policies overlook Māori institutional arrangements or impose externally driven retreat processes. Sharma et al. (2024) noted that the absence of Indigenous data sovereignty frameworks makes it difficult for Māori to monitor site-specific climate risks or manage retreat on their terms. The lack of access to geospatial tools that uphold tikanga can delay response efforts and increase exposure. In this way, disruption to tikanga results from physical hazard exposure and a risk that can be intensified by institutional design. Yletyinen et al. (2022) described how loss of access to mahinga kai and taonga species can initiate cascading social, economic and governance breakdowns within a few steps. Once these disruptions occur, they become difficult to reverse without targeted reconnection efforts.

3.4.4 Socioeconomic trends that may exacerbate the risk

A major issue that could threaten tikanga Māori and identity is the increasing number of Māori living in urban areas. This is a result of historical migration patterns and is now supported by current housing, economic, and planning systems. While most Māori now live in urban areas, many live at a physical and institutional distance from their ancestral lands, marae, and traditional governance structures (Ratana 2023; Rua et al. 2023). This distance can limit engagement in land-based practices, and with te reo Māori and tikanga. It happens primarily when urban infrastructure and housing models do not support collective living, whanaungatanga, or kaupapa Māori aspirations (Berghan 2021; Andersen 2024). Embedding Indigenous values in urban ecological restoration offers pathways for Māori to reassert place-based identity and regenerate mātauranga Māori in heavily modified environments. Tikanga-based restoration models, anchored in whakapapa, kaitiakitanga, and Indigenous governance, can also strengthen intergenerational resilience, when utilised in community-driven design (Walker et al. 2025). Many urban Māori live in housing systems largely shaped by colonial planning find these fragment kinship structures and reduce pathways for re-engagement with whenua and tikanga.

Johnson, Fisher, and Parsons (2023) have highlighted how climate adaptation policies that rely on emphasising infrastructure (such as water storage developments) or economic growth, tend to reproduce these fragmented kinship structures by assuming Māori will benefit through labour rather than through leadership or self-determination. In such contexts, wāhine Māori often absorb the combined burden of caregiving, sustained practice of tikanga, and precarious employment, increasing their vulnerability to institutional disconnection and policy marginalisation.

Without investment in kaupapa Māori-anchored urban spaces, or in strengthened pathways for reconnection to whenua, the long-term separation between place-based identity and daily life may deepen, particularly for rangatahi and those displaced by climate events. Tapsell (2022) argued that structural exclusions in planning systems mean that urban Māori face compounded risks of disconnection, both from their papakāinga and from decision-making frameworks. This concern was reinforced by Johnson, Parsons and Fisher (2023), who observed that Māori women's ability to maintain intergenerational well-being is significantly constrained when their leadership is not included in formal climate decision making.

This concern was reinforced by Erueti et al. 2023. They observed that many funding models and consultation processes continue to assume funding hapū./iwi will support all Māori. This assumption can marginalise many urban Māori and undermine efforts to develop tikanga-based relocation or reconnection options. This trend reinforces the importance of Te Tiriti-consistent adaptation planning supporting rural regeneration and tikanga-based urban resilience. Project Kāinga and housing initiatives documented in the Tai-o-Rongo Research Collective (2024)

© New Zealand Institute for Bioeconomy Science Limited (2026)

demonstrate how whakapapa-led planning can span urban and rural domains, reconnecting whānau to both whenua and one another. However, these strategies require policy settings that i) uphold mana motuhake; and ii) enable localised planning authority conditions. These settings are not yet embedded in many current frameworks (Johnson, Fisher & Parsons 2024).

3.4.5 Climate thresholds and tipping points

The risk of disruption to tikanga and hapū/iwi identity may be intensified when certain physical, legal, and social thresholds are exceeded. Biophysical thresholds may include losing access to marae, urupā, or kāinga due to flooding, coastal erosion, or damage from extreme weather events (Munro 2021; Bailey-Winiata et al. 2024). These events can disrupt regular use of Māori infrastructure and reduce opportunities for engagement in tikanga, wānanga, or communal governance. Institutional thresholds may also be reached when legal or policy settings, such as managed retreat frameworks, fail to account for Māori land tenure, relational governance, or whakapapa-based connections to place (Rout & Walker 2021; Pirini 2024). When significant sites are deemed uninhabitable or uninsurable, and relocation is not Māori-led or tikanga-aligned, the ability of whānau to maintain whakapapa to whenua may become constrained. The severity of these outcomes will vary across climate scenarios, with more frequent and intense hazard events under high-warming projections increasing the likelihood of the disruption to tikanga (Stephenson, Kawharu et al. 2023).

Tapsell (2022) identifies a threshold: when iwi and hapū are excluded from real decision-making (despite “partnership” language), their ability to protect their relationships with whenua is weakened. Johnson, Fisher, and Parsons (2023) show how this can play out with water-storage projects: big schemes often drive land-use intensification, which lifts demand for seasonal, lower-paid work (increasing labour exploitation risk), while governance and consent processes are run by agencies and industry with limited Māori authority. In practice, wāhine Māori are often sidelined when meeting times, technical rules, and board makeup do not align with their roles or priorities, so decisions about water on their whenua proceed without them, affecting both their livelihoods and well-being.

A tipping point may occur when whakapapa to place is broken to the extent that identity formation, intergenerational learning, and local leadership are significantly diminished or permanently altered. If multiple marae or urupā are abandoned or relocated without successful efforts to sustain their associated tikanga practices, this may lead to a decline in the regular practice of tikanga and reduce the influence of ahi kā and hapū-based governance (Andersen 2024). This could also disrupt whakapapa-based housing models and reduce the viability of whānau returning to whenua. Johnson, Parsons and Fisher (2023) emphasised that for wāhine Māori, the erosion of spiritual, linguistic, and caregiving roles linked to place can create a cascading loss of identity and well-being, particularly if trauma from historic displacement is re-triggered by state-led adaptation.

Once disrupted, these identity systems may be complex to re-establish, particularly if rangatahi are disconnected from ancestral lands or institutional frameworks do not enable reconnection pathways. Lambert and Mark-Shadbolt (2021) noted that when spiritual, relational, and linguistic ties to taonga (species) are severed, efforts to restore ecosystems must also restore the ancestral and place-based relationships that give those species meaning. This process becomes difficult without secure mandates for Māori governance or sustained support. While reconnection is possible, losing whenua-based anchors, such as mahinga kai, ahi kā, and whakapapa narratives, can lead to long-term fragmentation of identity if critical thresholds are crossed without support.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.4.6 Possible interactions with climate mitigation actions

Climate mitigation actions (particularly those involving large-scale land-use change, emissions regulation, and infrastructure investment) may exacerbate or help address the risk of disruption to tikanga: it depends on their design and focus.

Mitigation strategies that prioritise carbon sequestration through afforestation, for instance, may lead to the reclassification or repurposing of Māori land, especially whenua that is multiply owned in rural areas. If implemented without Māori leadership and tikanga-based planning, such actions may restrict access to ancestral sites or interfere with land-based tikanga, deepening disconnection from whenua (Rout & Walker 2021; Ministerial Inquiry into Land Use 2023). Similarly, urban mitigation initiatives, such as low-carbon housing intensification, may not align with kaupapa Māori housing models, potentially making it harder for Māori whānau to maintain or restore whakapapa-based living arrangements (Berghan, 2021; Andersen, 2024). Indigenous voices in urban and ecological planning are often included rhetorically but excluded structurally. They caution that without genuine power-sharing, Māori-designed solutions remain peripheral to urban resilience and ecological strategies, replicating colonial patterns under the guise of climate action (Walker et al., 2025).

Tapsell (2022) warned that climate mitigation policies can reinforce colonial governance by treating land as a carbon sink rather than a whakapapa-based living entity. This concern was reinforced by Johnson, Fisher, and Parsons (2023), who argued that mitigation projects embedded in market-based ideologies can disproportionately burden Māori communities by erasing pūrakau in favour of production or efficiency. Policies incentivising exotic monoculture forestry for carbon offsetting may displace aspirations for native regeneration and ahi kā restoration. Buckley et al. (2023) observed that while native afforestation offers co-benefits for tikanga revitalisation, current emissions trading mechanisms disproportionately favour high-yield exotic plantings. These make it harder for Māori to pursue mitigation strategies that align with tikanga and biodiversity goals.

Mitigation that supports Māori-led initiatives, such as papakāinga energy efficiency upgrades, marae-based solar projects, or low-emissions transport linked to kāinga, may strengthen hapū/iwi cohesion and enable reconnection with ancestral lands (Cram 2021; Hall et al. 2024). Skelton et al. (2023) and Paul-Burke et al. (2022) demonstrated that Māori-led seaweed cultivation and marine restoration projects can offer dual benefits: reducing emissions and reactivating tikanga-based marine practices. However, these projects often operate outside mainstream climate finance and remain vulnerable to environmental volatility and administrative neglect. Similarly, the Tai-o-Rongo Research Collective (2024) identified maramataka-based farming systems as inherently low-emissions and tikanga-based – yet disconnected from emissions reduction incentive schemes due to their relational rather than extractive logic.

3.4.7 Data gaps

There are significant data gaps in assessing the risk of disruption to tikanga and hapū/iwi identity for Māori. While qualitative evidence, such as interviews, kaupapa Māori housing reports, and Waitangi Tribunal submissions, provides rich insight into the importance of place-based identity, there is little national-scale data that tracks how climate-related displacement affects whakapapa ties, tikanga use, or intergenerational outcomes (Ratana 2023; Andersen 2024). Exposure pathways, such as coastal erosion or flooding, are usually mapped in general terms but not routinely linked to function or Māori settlement patterns. Similarly, there is a lack of monitoring of relocation impacts on marae use, urupā access, or language transmission. Sensitivity for Māori is under-documented in formal systems, especially regarding intangible impacts such as those on mana, tapu, or social cohesion.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Sharma et al. (2024) identified the absence of geospatial data infrastructures that uphold Māori data sovereignty as a key limitation for climate risk planning. Without access to tikanga-based, locally governed spatial data platforms, many iwi and hapū cannot monitor climate impacts on their assets accurately, or plan for relocation in ways that reflect tikanga. Adaptive capacity, such as Māori-led retreat protocols, kāinga regeneration, or reconnection strategies, exists but it is not systematically captured in planning tools or databases, limiting its visibility.

Tapsell (2022) and Erueti et al. (2023) criticised mainstream policy and climate assessments for overlooking 'relational indicators,' such as ahi kā continuity, te reo retention, and whakapapa resilience, as valid measures of adaptation or well-being. This limitation restricts the recognition of hapū/iwi well-being and the role of Indigenous frameworks in climate adaptation. Johnson, Fisher, and Parsons (2023) showed that wāhine Māori are notably excluded from data collection frameworks, despite playing central roles in adaptation, caregiving, and mātauranga Māori preservation. The Tai-o-Rongo Research Collective (2024) noted that place-based knowledge (such as of maramataka and tohu indicators) remains disconnected from national monitoring systems. This omission makes it harder to measure or respond to tikanga-based ecological thresholds that are not captured by Western environmental metrics.

3.4.8 Confidence level

The confidence in the evidence base for disrupting tikanga and hapū/iwi identity among Māori is moderate. The literature suggests that climate change threatens Māori infrastructure and practices, particularly marae, kāinga, and urupā, with studies highlighting impacts on whakapapa, tikanga, and intergenerational resilience (Berghan 2021; Kawharu 2023; Stephenson, Kawharu et al. 2023). However, there is limited quantitative and nationally disaggregated data, with key gaps including the lack of mātauranga-informed indicators in climate assessments, minimal monitoring of site vulnerability, and poor integration of Māori-led initiatives into formal planning (Skelton et al. 2023; Tai-o-Rongo Research Collective 2024; Tapsell 2022).

Māori exposure to climate hazards is well mapped, but the knock-on social and economic effects, especially for wāhine Māori, are not consistently measured across regions (see Johnson, Fisher & Parsons, 2024; Johnson, Parsons & Fisher, 2023). Therefore, while we are confident in the biophysical projections, we have limited data in tikanga-based impact assessments, particularly for gendered and intergenerational outcomes for hapū/iwi.

3.4.9 Risk severity summary

Table 12 presents the risk severity criteria for disruptions to tikanga and hapū/iwi identity across four levels of risk, from minor to extreme. It draws on published literature to assess how environmental change, displacement, and the erosion of relational practices may undermine cultural continuity and self-determination over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 12: Disruptions to tikanga and hapū/iwi identity risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Temporary disconnection from specific sites due to isolated weather events. • Tikanga-based practices remain largely intact with minimal interruption. • Community maintains whakapapa ties through localised response efforts.	• Managed retreat or erosion affects regional hapū/iwi. • Fragmentation of wāhi tapu and kāinga begins. • Tikanga is strained, particularly for wāhine-led practices.	• Wide-scale retreat, erosion or flooding severs ties to ancestral lands. • Marae abandonment or decline reduces cultural cohesion. • Tikanga frameworks lose continuity. • Intergenerational wellbeing declines.	• Total severance of whakapapa-based land relationships. • Systemic collapse of tikanga. • Intergenerational trauma compounded. • Identity recovery requires generational reconstruction.
Extent, duration and frequency of likely impacts	• Occasional flooding or erosion impacts. • Short-term displacement manageable within local networks. • Rituals and ceremonies adapted but continue.	• Recurring weather events disrupt access to marae, urupā, or kāinga. • Dislocation becomes cyclical in some rohe. • Rangatahi participation in tikanga declines.	• Sustained disconnection from significant sites. • Decline in tikanga use, te reo, and mana whenua expression. • Local governance and whānau cohesion weakened.	• Permanent loss of kāinga, marae, and wāhi tapu. • Interruption of mātauranga transmission across generations. • Institutional frameworks fail to uphold identity.
Ability to recover from likely impacts	• Recovery feasible through local whānau support or iwi-led planning. • Tikanga resumes post-disruption. • Emotional impacts contained by strong whanaungatanga.	• Recovery requires institutional support. • Tikanga-based responses develop but lack national backing. • Mental health and spiritual impacts increase	• Recovery dependent on major policy shifts. • Rebuilding tikanga requires long-term community investment. • Institutional disempowerment of Māori governance.	• Recovery only possible through constitutional and Treaty-aligned transformation. • Tikanga revival requires system redesign. • Whānau unable to sustain roles without systemic change.
Likely equity impacts	• Equity impacts are low. • Tikanga continuity and access to whenua remains secure. • Wāhine Māori maintain roles in identity transmission.	• Disproportionate burden on wāhine Māori in care and leadership roles. • Urban Māori disconnected from decision-making. • Exclusion from governance affects adaptation outcomes	• Equity gaps widen as Māori excluded from relocation frameworks. • Urban Māori experience identity dislocation. • Wāhine Māori face burnout.	• Structural exclusion entrenched across planning systems. • Wāhine Māori erased from adaptation leadership. • Māori collectives marginalised across rural and urban spaces
Likely impacts on te ao Māori	• Minimal disturbance to tikanga frameworks. • Maramataka and place-based learning continue uninterrupted. • Mātauranga transmission pathways remain active.	• Tikanga sustained but compromised. • Whakapapa transmission relies on isolated projects. • Limited recognition of tikanga in planning systems.	• Loss of ahi kā disrupts tikanga-based governance. • Te reo and tikanga decline. • Tikanga confined to project-level support without systemic backing.	• Collapse of relational knowledge systems. • Disconnection from whenua, te reo, tikanga and mātauranga becomes systemic. • Tikanga revival becomes generationally precarious.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 13) elaborates on the projected severity of disruptions to tikanga and identity for Māori under different warming scenarios, drawing on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. We utilised the Commission's scoring template for compiling our risk severity scores (see Appendix 3). By mid-century (1.5°C–2°C warming), more frequent climate events may make some significant sites harder to access or maintain. These effects may be more acute in low-lying coastal regions or areas with limited infrastructure resilience. At the same time, other places may face increasing drought or fire stress that gradually undermines site viability. By the end of the century (2.5°C–3.5°C warming), permanent loss or retreat from important places may become unavoidable in some areas. These risks are further intensified where managed retreat frameworks fail to accommodate collective tenure, as Tapsell (2022) noted, contributing to institutional exclusion and diminished sustained practice of tikanga.

Less granular spatial data on significant sites and limited integration of mana whenua perspectives in hazard planning systems heighten uncertainty. When adaptation infrastructure (e.g., water-storage schemes) proceeds while wāhine Māori are excluded from decisions and expected to shoulder unpaid environmental/economic burdens, cultural harm deepens and tikanga is disrupted (Johnson, Fisher, & Parsons, 2023). By contrast, when Māori-led adaptation is resourced, centred on tikanga, mātauranga, and wāhine Māori leadership, communities can maintain cohesion and identity (Johnson, Parsons, & Fisher, 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 13: Risk severity scores under different climate scenarios for disruptions to tikanga and hapū/iwi identity

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Disruptions to tikanga and hapū/iwi identity	Mātauranga Māori is actively revitalised in some sectors, but remains marginalised in national climate, research, and planning systems. Ecological degradation and institutional exclusion are beginning to erode the conditions needed for intergenerational transfer.	Ongoing environmental disruption, especially to keystone species and tohu, makes it harder to sustain place-based knowledge. Maramataka and seasonal practices may become less viable in affected regions, particularly where restoration efforts are underfunded or unsupported.	As ecosystem shifts accelerate, many communities may face the erosion of lived experience and loss of access to sites where mātauranga is maintained. Without coordinated structural support, knowledge transmission and cultural memory weaken, especially in under-resourced regions.	Systemic failure to embed mātauranga Māori in education, environmental management, and climate governance leads to widespread knowledge breakdown: practices, place-based memory, and intergenerational learning collapse in areas where ecosystems or access are irreversibly altered.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.5 Loss of indigenous knowledge systems

This section explores how climate change threatens the continuity of mātauranga Māori by disrupting the ecosystems, practices, and governance structures that sustain Indigenous knowledge systems. Table 14 presents a risk analysis of the loss of Indigenous knowledge systems, focusing on the impact of climate change on the transmission and practice of mātauranga Māori. It highlights the compounding effects of environmental degradation, policy exclusion, and institutional under-recognition on the continuity of practising maramataka, tohu, and place-based knowledge.

Table 14: Summary table for the climate risk of loss of Indigenous knowledge systems

Risk description	Loss of mātauranga Māori occurs as climate events destroy knowledge-rich environments (e.g. mahinga kai, marae, wāhi tapu), undermining intergenerational and site-specific knowledge transmission. This disproportionately affects wāhine Māori, whose knowledge maintenance and care roles are place-based.
Exposure (current, 2050, 2090)	Mātauranga Māori is already exposed due to ecosystem degradation, biodiversity loss, and damage to significant sites. Tohu-based indicators are disappearing, affecting tikanga. By 2090, high warming scenarios could severely limit viable knowledge practices unless supported by adaptation frameworks.
Sensitivity and adaptive capacity	Sensitivity is high because knowledge is often passed orally and through practice tied to specific species and sites. Adaptive capacity is visible in iwi-led innovations (e.g. tohu-based monitoring frameworks, maramataka) but remains underfunded and excluded from formal planning.
Compounding and cascading factors	Loss of mātauranga compounds vulnerability in governance, environmental management, and adaptation planning, as it limits locally grounded responses and may reduce the efficacy of adaptation systems that fail to integrate Indigenous knowledge.
Socioeconomic trends	Mātauranga Māori remains marginalised in education, planning, and governance. Funding gaps, policy exclusion, and procedural consultation fatigue undermine knowledge holders, particularly wāhine and kaumātua.
Climate thresholds and tipping points	Thresholds may be reached as taonga species vanish and environmental cues shift. Institutional tipping points occur when Mātauranga Māori is persistently excluded from decision-making frameworks, and knowledge holders cannot transmit their practices.
Possible interactions with mitigation	Mitigation may support or undermine mātauranga. Tikanga-based mitigation (e.g., maramataka-informed agriculture) enables revitalisation, while technocratic, emissions-focused schemes may sideline tikanga-based practices and reduce access to land.
Data gaps	No national tracking exists for mātauranga Māori continuity or maramataka use. Māori-led monitoring, wānanga, and knowledge holders are poorly represented in data systems. Oral traditions and lived practices are under-documented.
Confidence level	Confidence is moderate. Qualitative evidence and case studies are strong, but national metrics and spatial tracking are absent. Formal policy settings still lack te ao Māori frameworks for evaluating their impact/s on Māori well-being.

Extreme weather events destroy physical sites integral to the performance and transmission of mātauranga Māori, including wāhi tapu, mahinga kai, and marae, leading to accelerated erosion of iwi and hapū-specific environmental knowledge and hapū/iwi identity. As climate events destroy such knowledge-rich environments, mātauranga Māori becomes more vulnerable. Wilcox et al. (2024) responded directly to this risk by establishing a tohu-based monitoring framework for assessing environmental impacts and protecting iwi-specific environmental knowledge. Likewise, Hall et al. (2024) embed mātauranga Māori into sustainable architectural design and tikanga-based regeneration. Tapsell (2022) highlighted the fact that policy exclusions and fragmented land governance systems have contributed to existing vulnerabilities in knowledge transmission, which are now exacerbated by climate events. These effects are particularly acute for wāhine Māori, who

© New Zealand Institute for Bioeconomy Science Limited (2026)

often carry intergenerational knowledge roles that depend on access to significant sites (Johnson, Parsons & Fisher 2023).

Accelerated climate impacts on marine ecosystems undermine the ecological baselines on which mātauranga Māori relies. When taonga species or habitats disappear, the tohu used to guide harvests and maintain ecosystem balance vanish. Projects like Taura Kuku and Kohunga Kūtai (biodegradable mussel spat lines projects) demonstrate how Māori-led innovations can revitalise mātauranga Māori and reduce plastic pollution. However, these efforts are vulnerable to environmental volatility and lack funding (Paul-Burke et al. 2022; Skelton et al. 2023). Yates (2021) and Yates et al. (2022) argue that current governance and environmental monitoring tools often fail to incorporate these knowledge systems, typically prioritising technocratic or extractive approaches.

When species, waterways, and wāhi tapu are degraded or closed off, the everyday reference points for learning and practising mātauranga Māori disappear. This is not just “lost information,” it interrupts how knowledge is carried, taught, and renewed. Declines in taonga species remove the ecological scaffolding that sustains mātauranga Māori (Lambert & Mark-Shadbolt, 2021). Infrastructure-first adaptation can exacerbate this issue when the knowledge roles of wāhine Māori and kaumātua are overlooked, thereby accelerating the loss of Indigenous knowledge through institutional exclusion (Johnson, Fisher, & Parsons, 2023).

Research at Awhi Farms (Turangi), undertaken through the Tai-o-Rongo initiative (Tai-o-Rongo Research Collective 2024), has shown how applying tohu and maramataka frameworks can help rebuild Māori-led environmental observation systems. The initiative supports kaimahi in integrating mātauranga-based indicators into land-use decisions, particularly through seasonal, lunar, and terrestrial knowledge systems, as well as wānanga-based training in karakia, observation, and ceremony. These knowledge systems are not only applied to farming decisions: they are also actively used in environmental monitoring, fishing, planting, and weather interpretation, supporting climate mitigation and food resilience goals (Tai-o-Rongo Research Collective 2024). Nevertheless, Tai-o-Rongo leaders have cautioned that these systems remain precarious due to fragmented support and a lack of structural recognition in national climate planning frameworks (Tai-o-Rongo Research Collective 2024). Johnson, Parsons, and Fisher (2023) have noted that recognition without authority can lead to symbolic inclusion without addressing the restoration of knowledge transmission pathways or decision-making power.

Mātauranga Māori-informed monitoring models such as the Mauri Model and others reviewed by Morgan et al. (2021) demonstrate how Indigenous world views and indicators, especially those based on mauri and kaupapa Māori world views, can be formalised into assessment frameworks while remaining connected to the essence of that world view. These frameworks offer transparent ways to measure impacts on mahinga kai, wai māori (freshwater), and other taonga through iwi-specific indicators, enabling more tikanga-based and grounded responses to ecosystem change (Morgan et al. 2021). Sharma et al. (2024) also noted the importance of enabling Māori control over environmental data systems to ensure knowledge is not extracted or misused but governed according to tikanga. Revitalising knowledge systems in ecosystem restoration, and maramataka practices is increasingly urgent as climate change accelerates.

3.5.1 Exposure – current, 2050 and 2090

Mātauranga Māori, encompassing environmental observation, seasonal cycles, ceremony, and place-based knowledge, is integral to Māori resilience and identity. This knowledge is typically transmitted through lived practice, engagement with specific ecosystems, and intergenerational relationships. Climate change is increasingly exposing these systems to risk by disrupting the

environments, species, and Māori infrastructures through which they are maintained (Awatere et al. 2021; Johnson, Parsons & Fisher 2023; Tai-o-Rongo Research Collective 2024). Tapsell (2022) emphasised that exposure is compounded where land governance systems already weaken Māori ability to maintain continuous access to traditional sites.

Flooding, erosion, and marine changes create current exposure to risk of losing mātauranga Māori, which arises from the degradation of mahinga kai, wāhi tapu, and other knowledge-rich sites. Extreme events such as wildfires and cyclones have caused direct damage to sites used for instruction and practice, interrupting knowledge transfer opportunities (Munro 2021; Masters-Awatere, Young, & Graham 2022). In areas such as Taranaki and Waikato, practitioners have reported the disappearance or degradation of tohu used to guide activities like planting, harvesting, or fishing, as marine and terrestrial baselines shift (Mahuta & van Schravendijk-Goodman 2024; Wilcox et al. 2024). Lambert and Mark-Shadbolt (2021) noted similar disruptions in coastal communities where declining biodiversity erodes access to ecological and tikanga-informed baselines.

Looking to 2050, with global warming projected around 1.5°C–2°C, further exposure is likely if warming patterns continue to disrupt taonga species and ecosystems central to mātauranga Māori. The loss of customary species, such as kūtai, pāua, and harakeke, undermines raranga, rongoā, and use of mahinga kai (Short et al. 2023; Bulmer et al. 2024). Where habitats or species decline, associated knowledge, such as maramataka and ceremonial practice, may also become less viable in daily life (Paul-Burke et al. 2022; Johnson, Fisher & Parsons 2024; Skelton et al. 2023).

By 2090, under a warming of 2°C–3.5°C, there is a risk that environmental volatility could further constrain the expression and transmission of Indigenous knowledge. However, the extent of loss will be shaped by policy decisions, resourcing, and the extent to which Māori-led systems are supported. Community initiatives, such as the Tai-o-Rongo programme at Awhi Farms, have demonstrated how mātauranga Māori can be revitalised and applied in climate adaptation, provided the enabling conditions exist (Tai-o-Rongo Research Collective 2024). Hall et al. (2024) also noted that mātauranga Māori can be integrated into climate-responsive design and ecosystem restoration – but requires long-term partnerships and investment to scale effectively. Johnson, Parsons, and Fisher (2023) emphasised that failure to embed mātauranga Māori into adaptation design increases the likelihood of knowledge system loss by mid-to-late century.

Uncertainty remains regarding these losses' spatial extent and pace, partly because mātauranga Māori is locally specific and sometimes not formally documented. Moreover, climate impacts interact with longstanding policy barriers that have historically marginalised Indigenous knowledge from science and planning frameworks (Yates 2021; Johnson & Blackett 2024). Where mātauranga Māori is treated as supplementary or symbolic, rather than foundational, this can accelerate knowledge erosion by limiting its relevance and use in formal systems (Macpherson et al. 2023). Sharma et al. (2024) further argued that the lack of Māori-controlled data systems inhibits monitoring knowledge-specific climate risks, resulting in underreporting and planning blind spots.

Adaptation policies must integrate mātauranga Māori into environmental monitoring, land-use planning, and climate response frameworks to reduce risk exposure. Models such as the Mauri Model and tohu-based climate tools have demonstrated that this integration is possible, although it requires resourcing and institutional commitment (Morgan et al. 2021; Wilcox et al. 2024).

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.5.2 Sensitivity and adaptive capacity

Māori are highly sensitive to the risk of losing Indigenous knowledge systems, particularly mātauranga Māori, due to the close relationship between environmental integrity, place-based practices, and intergenerational learning. Mātauranga Māori is transmitted through direct engagement with landscapes, species, and seasonal cycles; therefore, when key ecosystems degrade or taonga species decline, the ability to maintain, practice, and pass on knowledge is threatened (Awatere et al. 2021; Johnson, Parsons & Fisher 2023; Mahuta & van Schravendijk-Goodman 2024). Tapsell (2022) also noted that institutional design exacerbates this sensitivity, which privileges extractive over relational land use, marginalising mātauranga Māori in decision making.

Sensitivity is especially acute for knowledge forms tied to specific locations and ecosystems, such as tohu-based indicators for planting and harvesting, lunar maramataka frameworks, and customary species management (Tai-o-Rongo Research Collective 2024). Where climate change alters these ecological baselines (e.g., through the disappearance of harakeke, pāua, or tuna), it not only affects food security or biodiversity but also interrupts the tikanga associated with those species and places (Paul-Burke et al. 2022; Skelton et al. 2023). This creates vulnerability for knowledge, especially where the loss of a practice or site means the loss of a knowledge lineage. Lambert and Mark-Shadbolt (2021) noted that as taonga species disappear, the loss is compounded by the weakening of intergenerational teaching networks and collective responsibility frameworks.

Māori adaptive capacity to protect and revitalise knowledge systems is significant but currently under-supported. Iwi, hapū, and whānau have developed a range of tikanga-based responses, including tohu monitoring systems (Wilcox et al. 2024), tikanga-based architecture (Hall et al. 2024), and community wānanga, to reassert Indigenous knowledge in planning and practice. These examples show that mātauranga Māori can support tikanga-based and ecological resilience when adequately resourced and recognised.

However, adaptive capacity is constrained by several systemic barriers. These include the marginalisation of mātauranga Māori within statutory planning processes, limited support for Māori expertise and kaumātua, and a tendency to treat mātauranga Māori as an optional or symbolic add-on rather than integral to planning processes (Macpherson et al. 2023; Yates 2021). In many cases, local knowledge systems remain undocumented or are vulnerable to being lost within a single generation if opportunities for practical engagement are not maintained (Morgan et al. 2021). Sharma et al. (2024) have identified that a lack of access to Māori-governed digital infrastructure inhibits climate-aligned knowledge archiving, making intergenerational retention harder to sustain under rapid environmental change.

This risk has a moderate to high degree of uncertainty, not because of ambiguity about its importance, but because there has been (and still is) limited formal monitoring of tikanga use and continuity. Much of this knowledge is held orally or through lived practice and is not captured systematically in national reporting frameworks or climate planning indicators. Consequently, risks to tikanga may be underestimated or overlooked in mainstream adaptation systems, even as climate change places additional strain on intergenerational knowledge transfer.

3.5.3 Compounding and cascading factors

The loss of Indigenous knowledge systems, including mātauranga Māori, maramataka, and site-specific tikanga, interacts with multiple other risks and can contribute to intensifying those risks over time. Climate-driven changes to ecosystems, such as the decline of keystone/taonga species,

© New Zealand Institute for Bioeconomy Science Limited (2026)

altered seasonal patterns, and damage to mahinga kai or wāhi tapu, reduce opportunities for hands-on learning and intergenerational transmission of knowledge (Awatere et al. 2021; Paul-Burke et al. 2022; Skelton et al. 2023). Due to marine and terrestrial instability, the disappearance of tohu further erodes the environmental baselines on which mātauranga Māori relies (Wilcox et al. 2024). These shifts can lead to a slow unravelling of place-based pūrakau and diminish the ability of Māori to maintain kaitiakitanga (Tai-o-Rongo Research Collective 2024).

Lambert and Mark-Shadbolt (2021) observed that repeated environmental shocks can break the links between taonga species and customary practices, leading to a compounding loss of both ecological knowledge and collective authority. Johnson, Parsons, and Fisher (2023) have argued that the breakdown of knowledge systems is not just a hapū/iwi well-being but a governance failure, as it erodes Māori capacity to design, implement, and evaluate their adaptation responses.

Loss of mātauranga Māori can also cascade into other domains of vulnerability. Where Indigenous knowledge systems are weakened, adaptation responses may become less tikanga-based or locally appropriate, leading to misaligned or ineffective interventions (Yates et al. 2022; Macpherson et al. 2023). The marginalisation of mātauranga Māori in formal planning and science advisory structures can reduce Māori participation in climate governance and affect the design of environmental monitoring, managed retreat, or resource use decisions (Morgan et al. 2021; Johnson & Blackett 2024). Erueti et al. (2023) noted that when Māori legal traditions and relational governance are excluded from policy processes, cascading losses may extend to decision-making capacity and institutional legitimacy. This is particularly critical when such processes relate to adaptation infrastructure (such as freshwater storage or land reallocation), when exclusion from knowledge governance can contribute to ‘epistemic disempowerment’ (loss of power over knowledge) (Johnson, Fisher & Parsons 2024).

This institutional exclusion may further undermine the resilience of Māori land- and sea-based economies and weaken whakapapa to whenua, affecting identity and well-being. While many iwi and hapū are leading efforts to revitalise knowledge through tohu monitoring, regenerative aquaculture, and community wānanga, these initiatives remain vulnerable to climate impacts themselves and often lack consistent institutional support (Hall et al. 2024; Wilcox et al. 2024). Tapsell (2022) noted that underfunded and unsupported Māori-led responses may experience burnout or loss of momentum, especially where climate events compound existing land tenure and governance inequities. The Tai-o-Rongo Research Collective (2024) also cautioned that without long-term structural support, mātauranga-based climate responses remain piecemeal and at risk of being dismissed as anecdotal. As a result, the risk of knowledge loss is cumulative and capable of amplifying vulnerability across social, environmental, and governance systems.

3.5.4 Socioeconomic trends that may exacerbate the risk

One key socioeconomic trend that may exacerbate the loss of Indigenous knowledge systems is the continued marginalisation of mātauranga Māori within mainstream planning, education, and climate governance structures. Despite increasing rhetorical recognition, many policy and funding systems still treat mātauranga Māori as supplementary or symbolic rather than foundational (Yates 2021; Macpherson et al. 2023). Tapsell (2022) and Erueti et al. (2023) emphasised that this structural exclusion, particularly in planning and adaptation policy, limits the roles of tohunga, kaumātua, and mātauranga Māori experts in shaping climate responses. Johnson, Parsons, and Fisher (2023) further argued that this symbolic treatment reflects a broader pattern of procedural exclusion, in which Māori knowledge is acknowledged but not empowered within institutional systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

This systemic positioning limits opportunities for tohunga, kaumātua, and kaitiaki to transfer knowledge in formal settings, and often excludes Indigenous frameworks from environmental monitoring, disaster response, or land-use planning processes (Morgan et al. 2021; Johnson & Blackett 2024). These exclusions are particularly acute for wāhine Māori and intergenerational caregivers (Johnson, Fisher & Parsons 2024) because of their knowledge being based in/on place.

At the same time, many whānau and hapū operate with limited resources to document, revitalise, or apply mātauranga Māori at scale, particularly in areas where Māori infrastructure or ecosystems have been degraded. Lambert and Mark-Shadbolt (2021) noted that the burden of care and monitoring has increasingly fallen on underfunded Māori communities, while formal science systems rarely recognise or integrate their contributions. Without structural support for place-based education and climate resilience grounded in tikanga, the knowledge systems that underpin Māori adaptation are at risk of further erosion.

3.5.5 Climate thresholds and tipping points

The risk of losing Indigenous knowledge systems may intensify when environmental and institutional thresholds are breached. Ecological thresholds, such as the decline of keystone/taonga species, degradation of mahinga kai, or disruption of seasonal cycles, can reduce the ability of Māori to observe tohu, follow maramataka, or engage in place-based learning (Paul-Burke et al. 2022; Wilcox et al. 2024). When taonga species like pāua, kūtai, or tuna become inaccessible - or climate shifts transform ecosystems, the settings in which mātauranga Māori is practised and transmitted may be significantly altered (Skelton et al. 2023; Tai-o-Rongo Research Collective 2024). Lambert and Mark-Shadbolt (2021) have cautioned that these environmental changes can trigger the loss of mātauranga Māori, as the ecological indicators on which it depends become unreliable or vanish.

Institutional thresholds may also be reached when policies and science systems continue to treat mātauranga Māori as a supplementary or optional knowledge base, excluding it from decision-making frameworks and limiting opportunities for tohunga or kaumātua to guide adaptation (Yates 2021; Macpherson et al. 2023). Sharma et al. (2024) noted that data systems not governed by Māori limit the ability to monitor and respond to these thresholds from a tikanga-based perspective. These risks are likely to intensify under higher-emissions scenarios, particularly where repeated hazards reduce opportunities for in situ learning. Johnson, Parsons, and Fisher (2023) emphasised that procedural barriers, such as consultation fatigue, lack of funding for wānanga, and exclusion from advisory boards, can form an invisible tipping point beyond which mātauranga Māori disengagement accelerates.

A tipping point could occur when the loss of environmental, social, or governance conditions renders the practical transmission of mātauranga Māori unviable in some areas. If knowledge holders are unable to pass on site-specific practices due to lost access, or if kaumātua are displaced or unsupported, the intergenerational continuity of tikanga, maramataka, and environmental stewardship may be disrupted (Hall et al. 2024; Masters-Awatere, Young, & Graham 2022). Tapsell (2022) suggested that when adaptation occurs without Māori-led frameworks, it can accelerate knowledge loss by imposing new governance structures that displace traditional ones. Given that much mātauranga Māori is held in lived practice rather than written form, the degradation of these conditions could result in the permanent loss of knowledge. While revitalisation efforts remain strong in many rohe, the disruption of tikanga, ecosystem decline, and institutional marginalisation may push some knowledge systems toward a threshold beyond which recovery becomes difficult. As climate pressures mount, addressing this risk will require environmental protection and structural support for Māori-led knowledge systems.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.5.6 Possible interactions with climate mitigation actions

Climate mitigation actions may interact with the risk of losing Indigenous knowledge systems in enabling and constraining ways.

On the one hand, the integration of mātauranga Māori into climate mitigation planning, such as using maramataka to guide low-emissions food production or applying tohu to monitor environmental change, can strengthen both emissions reduction outcomes and the resilience of Indigenous knowledge (Tai-o-Rongo Research Collective 2024; Wilcox et al. 2024). Māori-led initiatives in regenerative aquaculture, blue carbon restoration, and native reforestation have also demonstrated that when climate action is aligned with tikanga and relational governance, mitigation can become a pathway for knowledge revitalisation (Paul-Burke et al. 2022; Hall et al. 2024).

However, many mainstream mitigation policies treat emissions reduction as a technical or economic process, which may marginalise mātauranga Māori if it is not recognised as a valid planning or scientific framework (Macpherson et al. 2023; Yates 2021). For instance, carbon accounting models and emissions reporting regimes often prioritise Western metrics and may not accommodate place-based indicators. Johnson, Fisher, and Parsons (2023) observed that mitigation initiatives driven by infrastructure and productivity goals can override relational land-based practices, sidelining wāhine Māori and kaumātua who carry much of the intergenerational and seasonal knowledge required for tikanga-based mitigation.

The Tai-o-Rongo Research Collective (2024) further noted that without proper integration, mātauranga-based emissions indicators are excluded from monitoring frameworks, reducing Māori influence over land-use decarbonisation pathways. Tapsell (2022) warned that such frameworks may displace Indigenous governance by privileging commodified land uses, weakening opportunities for tikanga-based knowledge expression. Additionally, mitigation actions that alter land use or restrict access to ecosystems (e.g., afforestation or coastal infrastructure) may reduce opportunities for practising and transmitting Indigenous knowledge, particularly where these actions are externally designed or implemented without local Māori leadership. Sharma et al. (2024) argued that unless Māori data and governance systems are embedded in mitigation tools, there is a risk of “epistemic exclusion” and missed opportunities for co-benefit delivery.

Johnson, Parsons, and Fisher (2023) emphasised that climate mitigation can inadvertently contribute to knowledge loss if i) Māori are only invited to comment rather than lead; and ii) if Indigenous frameworks are evaluated solely through technocratic performance metrics. If this happens, poorly aligned mitigation approaches could contribute to knowledge erosion – whereas tikanga-based mitigation can support continuity and revitalisation of mātauranga Māori.

3.5.7 Data gaps

There are substantial data and measurement gaps relating to the exposure, sensitivity, and adaptive capacity of Indigenous knowledge systems, particularly mātauranga Māori, under climate change. While regional projects document the use of tohu, maramataka, and mātauranga-based restoration practices, these efforts are not tracked at a national level, nor are they consistently integrated into climate risk assessments or science frameworks (Tai-o-Rongo Research Collective 2024; Wilcox et al. 2024).

Sensitivity is particularly under-documented, with a limited understanding of how environmental degradation, species loss, and institutional exclusion affect knowledge systems. Sharma et al. (2024) noted that the lack of Māori-governed geospatial platforms and climate data systems limits the ability to track changes to Indigenous knowledge in real time or support tikanga-based

© New Zealand Institute for Bioeconomy Science Limited (2026)

decision-making. The Tai-o-Rongo Research Collective (2024) also observed that mātauranga-aligned indicators are often excluded from official climate data sets, making community-based evidence invisible to regional or national planners.

Adaptive capacity is also challenging to assess due to the absence of consistent tracking of Māori-led innovation, intergenerational transmission mechanisms, or funding for Mātauranga Māori experts. Johnson and Blackett (2024) argued that current adaptation policy settings lack monitoring frameworks that can recognise or evaluate the role of well-being or knowledge sovereignty in climate readiness. Johnson, Fisher, and Parsons (2023) added that the gendered and relational nature of much mātauranga Māori transmission means that systemic exclusion of wāhine from research funding, governance roles, or mitigation design further weakens its ability to measure and respond to knowledge decline.

3.5.8 Confidence level

The quality of available evidence is moderate, with strong conceptual and anecdotal agreement, but a lack of standardised metrics or longitudinal data. High agreement exists across qualitative sources that mātauranga Māori is increasingly at risk from climate-related ecological disruption, legal marginalisation, and the loss of Māori infrastructure (Yates 2021; Macpherson et al. 2023; Hall et al. 2024). However, the absence of mapping or formal inclusion of mātauranga Māori in environmental monitoring systems limits confidence in exposure estimates. Sharma et al. (2024) identified that current data systems do not support Māori authority over their knowledge indicators, resulting in fragmented reporting and limited responsiveness.

The Tai-o-Rongo Research Collective (2024) and Johnson and Blackett (2024) noted that national adaptation and science policies still lack a coherent methodology for capturing mātauranga Māori-informed change, leading to an underestimation of knowledge loss in formal assessments. Johnson, Fisher, and Parsons (2023) emphasised that institutional exclusion of Māori from climate mitigation and adaptation design undermines data sovereignty and the generation of relevant knowledge metrics. Given the variability in local knowledge retention and community support, it is uncertain how quickly tipping points might be reached. Overall, while the risk is well understood in concept and supported by expert and community testimony, the lack of systematic, te ao Māori-aligned data collection lowers confidence in the comprehensiveness of the evidence and has probably resulted in an underestimation of the risk in formal assessments.

3.5.9 Risk severity summary

Table 15 presents the risk severity criteria for loss of Indigenous knowledge systems across four levels of risk, from minor to extreme. It draws on published literature to assess how ecological disruption, institutional exclusion, and variable resourcing may influence the preservation or erosion of mātauranga Māori over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 15: Loss of indigenous knowledge systems risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Localised disruptions to practice or seasonal cycles. • Knowledge continuity preserved through whānau networks. • Ecosystem change visible but tikanga largely intact.	• Regional decline in access to knowledge-rich environments. • Knowledge transmission becomes fragmented. • Some maramataka practices interrupted.	• Widespread degradation of knowledge-holding ecosystems. • Tikanga and maramataka use declining across rohe. • Intergenerational loss accelerating.	• Collapse of environmental baselines essential to mātauranga. • Loss of whenua access makes knowledge practices unviable. • Systemic cultural erosion underway.
Extent, duration and frequency of likely impacts	• Short-term loss of specific tohu or harvesting sites. • Knowledge practice resumes as conditions stabilise. • Minimal interruption to intergenerational learning.	• Ongoing loss of tohu and taonga species. • Seasonal disjunction affects learning cycles. • Reduced practice in some rohe.	• Long-term disappearance of tohu. • Climate change reshapes seasonal logic. • Rituals, planting, and harvest guidance affected nationwide.	• Permanent loss of taonga species. • Intergenerational knowledge transfer breaks down. • No viable conditions for tikanga revival in some rohe.
Ability to recover from likely impacts	• Recovery possible through community wānanga or marae-based programmes. • Some institutional support is available. • Wāhine and kaumātua-led efforts sustained.	• Partial recovery through iwi-led projects. • Policy frameworks inconsistent. • Limited funding delays response. • Gaps in kaumātua support grow.	• Recovery requires long-term funding and structural reform. • Legal recognition lacking. • Tikanga recovery initiatives are under-resourced.	• Recovery is only possible through structural transformation. • System-wide overhaul required to sustain any continuity. • Tikanga recovery becomes generational project.
Likely equity impacts	• Minor inequities emerge in resource access. • Widespread access to knowledge transmission venues remains. • Minimal impact on wāhine Māori roles.	• Procedural exclusion of Māori knowledge holders. • Gendered roles under strain. • Inequity increases in policy participation.	• Māori disproportionately excluded from science and adaptation systems. • Wāhine Māori overburdened with restoration and care work. • Knowledge continuity unequally distributed.	• Knowledge holders excluded. • Wāhine Māori disempowered in climate leadership. • Institutional frameworks marginalise mātauranga.
Likely impacts on te ao Māori	• Maramataka, tohu and mātauranga remain integrated in planning. • Local indicators used consistently. • Tikanga maintained across generations.	• Mātauranga included symbolically but not empowered. • Loss of site-based learning. • Tikanga use declines in climate governance.	• Decline in te reo, tikanga, and place-based education. • Breakdown of whānau-led resilience. • Mātauranga Māori undermined.	• Tikanga collapses. • Loss of mātauranga Māori. • Mana whakahaere eroded.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 16) elaborates on the projected severity of loss of mātauranga Māori under different warming scenarios, drawing on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. We utilised the Commission's scoring template for compiling our risk severity scores (see Appendix 3). By mid-century (1.5°C–2°C warming), disruption of ecosystems may make it harder to observe tohu or maintain maramataka in some regions. These changes will be uneven, with some areas experiencing earlier loss of seasonal cues or species, while others may face slower erosion of knowledge due to incremental ecological shifts. By the end of the century (2.5°C–3.5°C warming), long-term ecological shifts and loss of access may lead to the breakdown of knowledge systems in areas where practice can no longer be maintained. This may particularly affect communities with fewer resources to sustain restoration, relocate practices, or archive lived experience. The risk worsens under higher emissions scenarios, especially without structural support for mātauranga Māori in the Research, Science and Innovation system, education, and environmental management.

Tapsell (2022) and Erueti et al. (2023) have cautioned that failure to embed Indigenous knowledge systems into climate governance will intensify loss and can lead to institutional failure to adapt effectively. We also note that uncertainty remains due to fragmented data on where and how mātauranga Māori is being revitalised, and how it is currently integrated, or excluded, from climate adaptation programmes.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 16: Risk severity scores under different climate scenarios for loss of Indigenous knowledge systems

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Loss of indigenous knowledge systems	Mātauranga Māori is actively revitalised in some sectors, but remains marginalised in national climate, research, and planning systems. Ecological degradation and institutional exclusion are beginning to erode the conditions needed for intergenerational transfer.	Ongoing environmental disruption, especially to keystone species and tohu, makes it harder to sustain place-based knowledge. Maramataka and seasonal practices may become less viable in affected regions, particularly where restoration efforts are underfunded or unsupported.	As ecosystem shifts accelerate, many communities may face the erosion of lived experience and loss of access to sites where mātauranga is maintained. Without coordinated structural support, knowledge transmission and cultural memory weaken, especially in under-resourced regions.	Systemic failure to embed mātauranga Māori in education, environmental management, and climate governance leads to widespread knowledge breakdown: practices, place-based memory, and intergenerational learning collapse in areas where ecosystems or access are irreversibly altered.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.6 Legal exclusion and governance failures

This section examines how legal exclusion and governance failures undermine Māori authority and participation in climate adaptation, increasing systemic risk and limiting equitable outcomes. Table 17 outlines the risk assessment for legal exclusion and governance failures, and highlights how Māori are structurally excluded from climate decision-making processes despite demonstrating leadership and capability. It also highlights how gaps in statutory authority, resourcing, and Te Tiriti-consistent governance frameworks increase Māori vulnerability to climate-related impacts.

Table 17: Summary table for the climate risk of legal exclusion and governance failures

Risk description	Māori are often excluded from emergency legislation, climate governance, infrastructure planning, heightening risks during managed retreat, adaptation funding, and disaster recovery.
Exposure (current, 2050, 2090)	Current exposure stems from informal recognition of Māori in emergency responses, such as Cyclone Gabrielle. By 2050-2090, risks will grow due to institutional misalignment with Māori land tenure and governance. Political and institutional variability adds uncertainty.
Sensitivity and adaptive capacity	High sensitivity due to structural exclusion from decision-making and planning. Adaptive capacity is strong in iwi-led frameworks but constrained by legal and institutional barriers that do not embed Māori governance or tikanga.
Compounding and cascading factors	Exclusion compounds risk across the other NCCRA domains, undermining planning, delaying adaptation, weakening social and governance systems, especially under increasing climate stress and Crown-centric legal settings.
Socioeconomic trends	Reliance on Eurocentric governance models exacerbates exclusion. Māori-led strategies are often informal and under-resourced, which can deepen inequality through relying on voluntary efforts and by providing a lack of access to planning infrastructure.
Climate thresholds and tipping points	Thresholds arise when Māori legal authority is not embedded in climate laws. Tipping points occur if exclusion persists under high climate pressures, resulting in disengagement and a loss of institutional legitimacy.
Interactions with mitigation actions	Market-based mitigation frameworks may exclude Māori unless collective governance is embedded. When properly supported, tikanga-based mitigation actions, such as carbon sequestration and maramataka-based stewardship, can strengthen Māori governance.
Data gaps	The lack of national metrics on Māori governance participation, data on adaptation funding, and Te Tiriti-consistent governance tracking limits visibility of risk magnitude and hinders effective response planning.
Confidence level	High confidence in qualitative data (e.g. reviews, inquiries). Low confidence in national monitoring or governance metrics. Exclusion is chronic, not episodic, and structural inertia limits reform.

Emergency legislation responses to extreme weather, such as the Severe Weather Emergency Recovery Act 2023, have increasingly sidelined Māori rights and participation (Rout et al. 2025). This exclusion heightens the risks associated with managed retreat, adaptation funding, and land-use decisions for Māori communities. Research by Hughes et al. (2021) and Stephenson, Kawharu et al. (2023) has revealed that Māori land tenure and collective governance are often overlooked in disaster response and infrastructure planning, resulting in inappropriate and inequitable outcomes. Stephenson, Kawharu et al. (2023) also identified several institutional barriers, including unstable political leadership, ad hoc engagement processes, and councils' reliance on iwi capacity. Tapsell (2022) reinforced this view, arguing that Māori inclusion is often symbolic and that Crown-led frameworks remain structurally misaligned with tikanga-based models. Johnson, Fisher, and Parsons (2023) further supported this by documenting how wāhine Māori in Te Tai Tokerau experienced governance exclusion under climate-adaptation infrastructure development/responses, despite leading community response efforts.

© New Zealand Institute for Bioeconomy Science Limited (2026)

In Hawke's Bay, Envirostrat Limited (2024) noted issues such as consultation fatigue and resource gaps among iwi; and called for governance models that were co-designed and grounded in mātauranga Māori alongside regional biodiversity visions. The legal and policy frameworks in Aotearoa frequently fail to reflect the constitutional status of Māori as Te Tiriti partners, especially during climate-related emergencies and adaptation planning. Cram (2021) highlighted the self-organisation of Māori communities during the Canterbury earthquakes and COVID-19 lockdowns, showcasing their substantial capability and commitment rooted in manaakitanga and mahi aroha. However, these community-led responses often occurred without adequate support from mainstream institutions. Lambert and Mark-Shadbolt (2021) showed similar dynamics in biosecurity contexts. Māori-led responses to kauri dieback and myrtle rust infections have operated independent of formal governance structures, revealing institutional blind spots.

Paul and Ratana (2022) drew attention to the systemic barriers faced by rangatahi Māori in the housing and governance realms, underscoring a persistent legal exclusion. Yates et al. (2022) advocated restructuring governance frameworks to embed mātauranga Māori, relationality, and Indigenous co-leadership. The marginalisation of Māori voices in local and central government climate responses often results in policies that misalign with the needs and world views of Māori communities. Thus, recognising Māori authority in governance is not merely a Te Tiriti obligation; it is essential for achieving equitable, place-based, and tikanga-based climate adaptation. Sharma et al. (2024) called for Māori data governance and planning autonomy to ensure climate tools and adaptation infrastructure are aligned with tikanga.

Despite growing examples of co-design across research and iwi-led planning, Māori participation in emergency legislation and climate governance remains structurally constrained. As noted in a case study by Pohatu and Walker (2021), legacy exclusion from catchment management and erosion control efforts continues to shape institutional arrangements, despite formalised relationships with the Crown. These examples underscore the risk of emergency powers bypassing or eroding Te Tiriti-based protections. Kawharu (2023) further noted that many Māori communities lack relationships with local government to progress climate action, and that marae are not adequately resourced to establish policy units to respond to such emergencies. This fragmentation exacerbates the disconnect between Crown-led planning and place-based rangatiratanga. Erueti et al. (2023) also pointed to legal procedural barriers that prevent Māori from exercising customary authority during climate crises, arguing for structurally embedded co-governance mechanisms.

While Māori leadership in sustainable aquaculture and fisheries innovation is evident, existing legal and policy settings often struggle to accommodate Māori models of collective governance and intergenerational stewardship. Reviews of projects have demonstrated that co-governance in the marine domain is fragmented, with Māori often relegated to stakeholder roles rather than governance partners (Macpherson et al. 2023; McLellan & Mika 2024). The quota management system, marine consent regimes, and emergency legislative responses are not designed for collective rights, intergenerational values, or community-based resilience strategies. These barriers delay adaptation responses and entrench historical exclusions. Tapsell (2022) emphasised that these exclusions are not technical oversights, but consequences of structurally Euro-centric legal systems that continue to overlook Indigenous law and responsibility.

3.6.1 Exposure – current, 2050 and 2090

Māori exposure to climate risks is shaped by environmental conditions and the structure of legal and governance systems. Many of the barriers that Māori communities face during climate-related emergencies and adaptation planning are institutional, stemming from frameworks that do not adequately reflect Te Tiriti o Waitangi or Māori governance structures (Johnson, Fisher & Parsons

2024; Stephenson, Kawharu et al. 2023; Department of Internal Affairs 2024). Tapsell (2022) and Erueti et al. (2023) considered that colonial legal architectures dominate crisis governance, sidelining Māori authority even when community responses demonstrate superior agility and cohesion.

Māori legal and governance exposure is evident in emergency responses to recent weather events, including Cyclone Gabrielle. Multiple reviews of Cyclone Gabrielle responses found that Māori entities were engaged informally or ad hoc, rather than through formalised roles in planning and response systems (Bush International Consulting 2024; Pirini 2024). This limited recognition can reduce the effectiveness of Māori-led initiatives and result in responses that are misaligned with tikanga. Despite strong Māori capability in emergency response, welfare provision, and local planning, many iwi and hapū continue to operate without statutory authority or secure funding for this work (Cram,2021; Kawharu 2023).

By 2050 (1.5°C–2°C warming), an increased frequency of climate-related emergencies may further expose Māori to the limitations of existing legislative and governance systems. For example, current emergency legislation does not guarantee Māori decision-making roles or embed tikanga-based planning principles (Rout et al. 2025). Similarly, legal settings that govern land use, marine resources, and managed retreat do not consistently accommodate collective land tenure or place-based responsibilities such as ahi kā or kaitiakitanga (Ministerial Inquiry into Land Use 2023; Andersen 2024). This can result in governance fragmentation, delays in adaptation, and marginalisation from funding streams (Whitehead & Walker 2021; Envirostrat Limited 2024). Despite their effectiveness, Lambert and Mark-Shadbolt (2021) found that Māori-led responses were isolated from funding and policy systems even in climate-sensitive domains like biosecurity.

Looking toward 2090 (with 2°C –3.5°C warming), if legal exclusion is not addressed, the cumulative effect may be compounded for Māori communities required to engage in managed retreat, infrastructure decision making, or marine spatial planning. In these contexts, exposure arises when decision-making structures fail to include Māori as partners or rights-holders, and when adaptation is framed through technocratic approaches that are incompatible with Māori law and governance (Macpherson et al. 2023; Mika & MacDonald 2024).

The uncertainty in this risk stems less from biophysical climate models and more from political and institutional settings. While legal reforms are possible and underway in some areas, their outcomes are not guaranteed and may vary across regions and political cycles (Yates 2021; Papa Pounamu 2022). Iwi and hapū also experience variability in capacity and resourcing, which affects their ability to influence or engage with legal processes (Stephenson, Kawharu et al. 2023). Sharma et al. (2024) have noted that the lack of Māori data sovereignty further complicates exposure assessments, as Māori communities cannot reliably track or contest institutionally defined risks.

Nevertheless, Māori-led governance models, such as those developed in aquaculture, housing, and catchment co-management, demonstrate the feasibility of more equitable systems when supported by appropriate frameworks (Berghan 2021; Pohatu & Walker 2021; Rout et al. 2023). Reducing exposure in this domain will depend on embedding these approaches within legislation, institutional norms, and funding structures over the long term.

3.6.2 Sensitivity and adaptive capacity

Māori are highly sensitive to the effects of legal exclusion and governance failures because climate adaptation and disaster response systems rely heavily on institutional frameworks that have historically marginalised Māori authority. Despite explicit Te Tiriti obligations, current legal instruments and planning processes frequently relegate Māori to advisory or consultative roles

© New Zealand Institute for Bioeconomy Science Limited (2026)

rather than embedding them as decision-making partners. This undermines tino rangatiratanga (self determination) and limits the ability of Māori to shape responses to climate risk in ways that are grounded in tikanga and place-based governance (Johnson, Fisher & Parsons 2024; Stephenson, Kawharu et al. 2023; Department of Internal Affairs 2024). Erueti et al. (2023) argued that this structural exclusion reinforces dependency on Crown institutions, undermining the autonomy of whānau and hapū to enact their own climate and disaster strategies.

The sensitivity is especially pronounced during emergencies, where legal structures, such as those underpinning the Severe Weather Emergency Recovery Act 2023, enable the rapid exercise of Crown power without guaranteed Māori participation. Reviews of responses to Cyclone Gabrielle and other recent events have found that Māori engagement was often informal, fragmented, or delayed, despite iwi and hapū playing pivotal roles in community welfare and response delivery (Bush International Consulting 2024; Pirini 2024). These patterns of exclusion have weakened coordination, eroded trust, and limited the effectiveness of locally led adaptation initiatives. Tapsell (2022) further noted that such exclusion is not an oversight but a symptom of legal systems that privilege market-based and individualistic frameworks over collective, tikanga-based models.

Māori capacity in climate adaptation is demonstrated through a wide range of iwi-led planning, climate strategies, and governance models. These include co-management arrangements in catchments like the Waiapu River (Pohatu & Walker 2021), iwi-led climate and freshwater strategies grounded in maramataka and whenua tuku iho (Tai-o-Rongo Research Collective 2024; Wilcox et al. 2024), and innovations in kaupapa Māori housing and disaster planning such as papakāinga, kāinga regeneration, and Māori-led emergency responses (Berghan 2021; Cram 2021; Munro 2021; Andersen 2024; Hall et al. 2024). These initiatives all demonstrated strong place-based governance and resilience, yet they often operated without formal recognition or structural support. Lambert and Mark-Shadbolt (2021) documented similar limitations in biosecurity governance, where Māori-led responses to ecological threats were effective but unsupported by formal state systems. Johnson, Parsons, and Fisher (2023) reinforced this view by observing that while Māori communities often fill climate leadership gaps, their ability to do so is constrained by a lack of legal standing and institutional resourcing.

Institutional readiness to support Māori governance is variable across regions and agencies. While some councils and national bodies have taken steps toward partnership, many still lack the necessary structural tools, legal mandates, or funding mechanisms to embed Māori governance meaningfully (Papa Pounamu 2022; E Oho! Awakening Aotearoa 2023). This has contributed to a reliance on voluntary labour and ad hoc relationships, which are not sustainable under conditions of increasing climate stress (Kawharu 2023; Andersen 2024).

There is relatively low uncertainty about the persistence of this risk. Numerous reports, including inquiries, policy reviews, and submissions, have documented the consistent exclusion of Māori governance in emergency, climate, and environmental law contexts (Cram 2021; Ministerial Inquiry into Land Use 2023). The challenge lies not in diagnosing the issue, but in overcoming the policy inertia, fragmented authority, and institutional resistance that prevent structural reform.

3.6.3 Compounding and cascading factors

Legal exclusion and governance failures are central risks that compound the effects of other climate-related challenges and, in many cases, shape the capacity of Māori to respond to them. When Māori are excluded from statutory decision-making roles or reduced to advisory functions, the ability to embed place-based values, tikanga, and intergenerational governance in climate planning is limited (Stephenson, Kawharu et al. 2023; Department of Internal Affairs 2024). Emergency laws, resource management frameworks, and climate legislation often lack

© New Zealand Institute for Bioeconomy Science Limited (2026)

mechanisms to uphold Te Tiriti o Waitangi or accommodate collective land governance, constraining the development of locally relevant responses (Pirini 2024; Rout et al. 2025). This exclusion can delay response coordination, restrict access to adaptation funding, and reduce Māori influence in processes such as managed retreat or infrastructure planning (Papa Pounamu 2022; Ministerial Inquiry into Land Use 2023). Tapsell (2022) and Erueti et al. (2023) have stressed that these delays are not just procedural, but that they fundamentally erode Māori governance authority and may lead to long-term fragmentation of Indigenous institutions. Johnson, Fisher, and Parsons (2023) added that such exclusions burden Māori, especially wāhine Māori, with unpaid, high-risk leadership roles that are not institutionally recognised, contributing to structural fatigue and systemic inequity.

These governance gaps also generate cascading impacts across other domains. For example, when Māori are not formally included in emergency response planning, the burden of care and coordination often falls informally on marae and hapū without adequate resourcing (Cram 2021; Bush International Consulting 2024). This increases pressure on overstretched infrastructure and can lead to burnout or reduced capacity over time (Kawharu 2023). Similarly, when mātauranga Māori is not structurally embedded in environmental monitoring or climate legislation, risks to ecosystems and mātauranga Māori may be under-recognised or poorly managed (Yates et al. 2021; Wilcox et al. 2024). Lambert and Mark-Shadbolt (2021) have provided evidence that Māori-led responses to ecological crises, such as myrtle rust and kauri dieback disease, have filled critical governance gaps. However, without legal authority, these contributions remain vulnerable to marginalisation.

Thus, exclusion from governance limits adaptive action and may indirectly contribute to the erosion of tikanga, disconnection from whenua, and underinvestment in Māori-led climate strategies. While Māori-led planning and co-governance models continue to expand, the absence of binding legislative mandates remains a key factor amplifying systemic vulnerability. Sharma et al. (2024) has noted that without Indigenous control over decision-making infrastructure, such as data, monitoring systems, and planning tools, even co-designed efforts may fail to deliver equitable or durable outcomes.

3.6.4 Socioeconomic trends that may exacerbate the risk

A key socioeconomic trend that may exacerbate legal exclusion and governance failures is the continued institutional reliance on governance models and legal instruments that are poorly aligned with Māori collective rights, intergenerational stewardship, and relational decision-making. Many statutory frameworks, such as those governing emergency management, land use, or resource planning, remain centred on Euro-centric, individualised property and governance structures, which do not accommodate tikanga-based systems or kaupapa Māori models (Whitehead & Walker 2021; Rout et al. 2025). This misalignment is reinforced by uneven institutional capability across government and local authorities, where efforts to engage with Māori often lack consistency, funding, or legal mandate (Papa Pounamu 2022; Stephenson, Kawharu et al. 2023). As a result, Māori participation in climate governance is often informal, under-resourced, and reliant on voluntary labour or goodwill, rather than embedded in durable, Te Tiriti-consistent decision-making structures (Cram 2021; Kawharu 2023).

Erueti et al. (2023) further argued that without structural reform, this reliance on informal engagement perpetuates Māori dependency on Crown goodwill, rather than enabling tino rangatiratanga. Lambert and Mark-Shadbolt (2021) showed that similar patterns exist in biodiversity and biosecurity governance, where Māori capability is underused due to policy and institutional inertia. Johnson, Parsons, and Fisher (2023) reinforced this view by showing how

© New Zealand Institute for Bioeconomy Science Limited (2026)

policies that depend on Māori capacity without transferring authority reproduce structural inequality, especially for wāhine Māori in frontline leadership roles. The Tai-o-Rongo Research Collective (2024) also showed how Māori climate leadership remains marginalised in institutional settings despite decades of environmental work grounded in tikanga Māori.

Sharma et al. (2024) also emphasised that Māori collectives lack equitable access to climate-related data and planning infrastructure, which compounds their exclusion and reduces opportunities for long-term governance innovation. Without legislative reform and systemic investment in Māori governance capacity, this trend will continue to limit Māori influence over adaptation planning and emergency response, contributing to delayed, fragmented, or tikanga misaligned outcomes.

3.6.5 Climate thresholds and tipping points

The severity of legal exclusion and governance failures may escalate when institutional and policy thresholds are exceeded, particularly those determining decision-making authority in a climate response. A critical threshold is reached when emergency, land-use, and climate adaptation frameworks fail to uphold Māori governance rights under Te Tiriti o Waitangi or do not structurally accommodate Māori land tenure and tikanga-based planning (Whitehead & Walker 2021; Rout et al. 2025). This is evident in emergency management legislation and managed retreat proposals, where Māori are often positioned as stakeholders rather than decision makers (Department of Internal Affairs 2024; Pirini 2024). When Māori are excluded from co-governance arrangements or denied access to adaptation funding because of administrative or legal barriers, the adaptive capacity of communities is constrained, and reliance on informal, unfunded systems increases (Papa Pounamu 2022; Kawharu 2023). Tapsell (2022) has warned that repeated procedural exclusion under emergency conditions risks normalising Crown-centric governance, pushing Māori further to the periphery of climate decision-making. Lambert and Mark-Shadbolt (2021) also cautioned that failure to empower Māori leadership in environmental governance creates feedback loops of social and ecological vulnerability. Johnson, Fisher, and Parsons (2023) have emphasised that when Māori-led responses are structurally unsupported, despite demonstrated capability, this creates governance saturation and fatigue, particularly for wāhine Māori operating without institutional backing.

These institutional thresholds may be exceeded more frequently under high-climate-stress scenarios, where governance demands intensify, and resource gaps widen. A tipping point could occur when cumulative exclusion leads to systemic mistrust, disengagement, or erosion of Māori-led governance structures. If adaptation responses, such as managed retreat, infrastructure investment, or disaster planning, consistently proceed without embedding Māori governance, the result may be the loss of confidence in statutory processes and weakening of place-based decision-making (Cram 2021; Stephenson, Kawharu et al. 2023). The Tai-o-Rongo Research Collective (2024) has warned that repeated exclusion erodes governance legitimacy, the transmission of tikanga, and the sustained practice of tikanga linked to place.

Not including Māori governance in climate adaptation may also reduce opportunities to embed mātauranga Māori in planning, affecting ecosystem management and the sustained practice of tikanga. While many iwi and hapū continue to lead their own climate and emergency planning efforts, persistent exclusion from legal authority and resource control could push some communities into a reactive or unsupported governance state. Sharma et al. (2024) noted that such conditions are exacerbated when Māori lack sovereign control over climate data systems and cannot shape the evidence base for adaptation policy. Without Te Tiriti-consistent legal reform, the

© New Zealand Institute for Bioeconomy Science Limited (2026)

risk of structural disengagement may increase as climate pressure intensifies, making the restoration of Māori governance roles more challenging over time.

3.6.6 Possible interactions with climate mitigation actions

The design and implementation of climate mitigation actions can reinforce or reduce Māori exclusion from governance systems, depending on how Te Tiriti obligations, collective land rights, and Māori decision-making structures are embedded in policy.

i) Mitigation frameworks that prioritise market mechanisms (such as emissions trading or carbon offsetting) without structural support for Māori governance may exacerbate exclusion, particularly if these tools are not adapted to accommodate collective land tenure, kaupapa Māori planning, or whānau/hapū authority (Rout et al. 2023; Rout et al. 2025). For example, Māori collectives may be left out of emissions reduction funding streams or transition strategies if eligibility criteria and decision-making processes are not aligned with tikanga-based models (Papa Pounamu 2022; Mika & MacDonald 2024). Tapsell (2022) criticised these frameworks for reproducing colonial values of land commodification and legal personhood, which conflict with Māori conceptions of whenua as a living ancestor and tikanga-based approaches.

ii) Mitigation initiatives that are co-governed or developed through Te Tiriti-consistent partnerships may reduce exclusion and support the restoration of Māori authority in climate governance. Māori-led carbon sequestration, clean energy, and native reforestation projects offer potential co-benefits for climate mitigation and rangatiratanga, particularly if policy settings ensure Māori control over how land, resources, and data are used (Berghan 2021; Cram 2021). The Tai-o-Rongo Research Collective (2024) noted that mitigation grounded in maramataka, tohu, and place-based stewardship can reduce emissions and strengthen Indigenous governance, but only where institutional frameworks enable long-term Māori leadership.

Climate change may also increase demand for more inclusive and devolved governance systems, particularly as Crown agencies seek locally led responses to emissions reduction in diverse regions. However, without deliberate structural reform, the risk remains that Māori governance will continue to be marginalised in mitigation planning, thereby compounding systemic exclusion. Sharma et al. (2024) has warned that unless Māori data sovereignty and relational indicators are embedded in mitigation reporting systems, emerging climate technologies may reinforce monocultural planning and exclude tikanga-based solutions. Johnson, Parsons, and Fisher (2023) also cautioned that even well-intentioned adaptation or mitigation efforts can reinforce exclusion if Māori knowledge, leadership, and relational governance are not considered foundational rather than supplementary.

3.6.7 Data gaps

There are moderate to significant data gaps relating to Māori participation in climate decision making, particularly regarding legal and governance aspects. While numerous inquiries and reports (e.g., Ministerial Inquiry into Land Use 2023; Department of Internal Affairs 2024) and submissions to the Emergency Management Bill (introduced June 2023) document patterns of exclusion, these are not backed by consistent national metrics that track Māori involvement in governance roles across emergency management, adaptation planning, or mitigation processes. Data on Māori access to adaptation funding, participation in co-governance arrangements, or structural barriers to legal authority is fragmented and often case-specific (Papa Pounamu 2022; Kawharu 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Sensitivity is particularly under-measured in institutional terms; that means there is limited assessment of how repeated exclusion affects Māori capacity to exercise tino rangatiratanga or how fragmented governance systems impact response coordination. Johnson, Fisher, and Parsons (2023) have highlighted that data systems tend to reflect Crown-defined governance indicators, obscuring the leadership roles and governance innovations led by wāhine Māori and hapū-level institutions. While present in many iwi and hapū initiatives, adaptive capacity is not well tracked or resourced across regions, resulting in limited visibility. Sharma et al. (2024) have noted that the absence of Indigenous data sovereignty tools and planning dashboards prevents Māori from recording, analysing, or responding to governance-related climate risks in a timely or tikanga-based manner.

3.6.8 Confidence level

Confidence in the direction and persistence of the risk is high, supported by consistent findings across multiple official reviews, community submissions, and Māori-led reports (Cram 2021; Stephenson, Kawharu et al. 2023; Pirini 2024). The evidence is clear: Māori are regularly excluded from formal climate governance processes, and statutory tools are not designed to uphold Māori legal authority. However, confidence in the magnitude and distribution of this risk is lower due to a lack of national-level monitoring systems or structural accountability mechanisms. For example, there is a lack of consistent data on the proportion of Māori-led proposals funded under adaptation frameworks or the presence of Māori decision-making roles in local climate governance. Johnson, Fisher, and Parsons (2023) underscored this gap by documenting how institutional measures of governance capacity frequently omit informal or community-led leadership, particularly by wāhine Māori.

Tapsell (2022) and Erueti et al. (2023) emphasised that exclusion is chronic and systemic, not episodic, and that qualitative data show that there has been erosion of long-term trust and governance capacity. Sharma et al. (2024) further pointed out that in the absence of tikanga-based data systems, climate governance performance is not accurately measurable for Māori communities. As such, while the evidence base is strong in qualitative terms and enjoys high agreement, the absence of quantitative tracking limits precision and is likely to lead to underestimation of how pervasive and consequential governance exclusion is under climate pressure. The Tai-o-Rongo Research Collective (2024) also observed that without structural indicators of tikanga-based governance, Māori-led innovation in climate and land-use planning remains invisible in most national assessments.

3.6.9 Risk severity summary

Table 18 presents the risk severity criteria for legal exclusion and governance failures across four levels of risk, from minor to extreme. It draws on published literature to assess how institutional inertia, fragmented statutory recognition, and the absence of Māori governance authority may undermine climate adaptation effectiveness over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 18: Legal exclusion and governance risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Isolated exclusion from climate planning processes. • Māori governance roles present in localised contexts. • Informal participation pathways available.	• Regional inconsistencies in legal authority. • Governance participation fragmented. • Planning processes overlook Māori frameworks.	• National frameworks exclude Māori authority. • Governance decisions made without Māori leadership. • Tikanga-based leadership bypassed.	• Systemic exclusion from climate governance. • Māori leadership unrecognised in law. • Te Tiriti obligations bypassed during crises.
Extent, duration and frequency of likely impacts	• Short-term exclusion from specific projects or responses. • Some delays in inclusion during emergencies. • Gaps are visible but correctable.	• Delays in funding, representation and emergency authority. • Repeated informal engagement pathways. • Slow recognition of iwi capability.	• Long-term exclusion across planning sectors. • Emergency powers override Māori roles. • Loss of funding and land-use rights grows	• Chronic disconnection from adaptation systems. • Persistent emergency exclusion. • Māori governance rendered invisible in reforms.
Ability to recover from likely impacts	• Recovery possible through targeted partnerships. • Local Te Tiriti-based solutions mitigate risks. • Voluntary efforts remain sustainable.	• Recovery possible through targeted partnerships. • Local Te Tiriti-based solutions mitigate risks. • Voluntary efforts remain sustainable.	• Recovery requires legal reform and institutional redesign. • Governance fatigue grows. • Wāhine leadership unsupported.	• Recovery unlikely without constitutional change. • Institutional legitimacy fails in Māori communities. • Trust, capacity, and cohesion degraded
Likely equity impacts	• Equity impacts limited to procedural gaps. • Tikanga considered but inconsistently applied. • Institutional trust remains intact.	• Māori capability used without resourcing. • Wāhine Māori roles under-recognised. • Local inequities become structural	• Structural exclusion entrenched in policy and law. • Access to mitigation or adaptation restricted. • Disparities in funding and data access deepen.	• National systems perpetuate Māori exclusion. • Climate infrastructure built without Māori input. • Equity failures span generations.
Likely impacts on te ao Māori	• Minor erosion of Māori authority. • Some loss in tikanga-based governance. • Institutional inclusion still viable.	• Hapū/iwi governance in climate planning strained. • Marae-based responses fill policy gaps. • Te Tiriti relationships symbolic.	• Tikanga-based authority eroded. • Māori infrastructure unsupported. • Māori governance marginalised	• Collapse of intergenerational governance structures. • Te Tiriti undermined by Crown authority. • Tikanga-based systems become ceremonial only.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 19) elaborates on the projected severity of increased legal and governance vulnerabilities for Māori under different warming scenarios, drawing on evidence to illustrate how compounding risks and governance gaps may shape outcomes over time. We utilised the Commission's scoring template for compiling our risk severity scores (see Appendix 3). By mid-century (1.5°C –2°C warming), growing pressure on adaptation and recovery systems may increase the consequences of exclusion, especially if Māori-led strategies remain unsupported. Increased frequency of climate-related emergencies may expose gaps in authority, leading to delayed or inappropriate responses for Māori communities. By the end of the century (2.5°C –3.5°C warming), exclusion could compound across sectors, weakening community trust, reducing responsiveness, and widening inequality. These cumulative impacts may erode legitimacy and operational effectiveness in climate governance systems.

This risk does not vary as directly with emissions scenarios as physical risks, but its impact may become more serious as climate pressures increase. Uncertainty around the risk stems from slow and uneven reform trajectories, a lack of clear mandates for Māori leadership in statutory frameworks, and inconsistent recognition of Māori governance models in legislation. Without reform, Māori may face escalating governance barriers just as effective, community-led responses are most needed. Lambert and Mark-Shadbolt (2021) and Sharma et al. (2024) have both demonstrated viable pathways for reform, but their work also underscores how under-recognition and institutional inertia continue to delay Māori-led governance inclusion. Whether this risk intensifies or diminishes will depend on the pace and substance of structural change, not just procedural participation.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 19: Risk severity scores under different climate scenarios for legal exclusion and governance

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Legal exclusion and governance	Māori governance models are inconsistently recognised in statutory frameworks. While participation is improving in pockets, legal mandates for Māori leadership remain weak, and exclusion continues to shape planning and decision-making across key sectors.	Climate pressure exposes the consequences of systemic exclusion. Gaps in authority and statutory recognition undermine responsiveness to emergencies, delay local adaptation efforts, and erode trust in public systems among Māori communities.	As the frequency and scale of climate-related events increase, institutional disconnection becomes entrenched. Exclusion from planning and decision-making exacerbates inequality and weakens the legitimacy of adaptation systems, particularly where Māori leadership is marginalised.	Governance systems risk systemic failure where Māori remain excluded. Institutional legitimacy declines, and fragmented authority leads to misaligned or unjust responses. Without structural reform, Māori are left outside formal governance mechanisms just as climate risks intensify.

© New Zealand Institute for Bioeconomy Science Limited (2026)

3.7 Increased health vulnerabilities

This section assesses the climate-related health vulnerabilities Māori face, focusing on how structural inequities, ecological degradation, and governance exclusion compound health risks and reduce adaptive capacity. Table 20 provides a structured synthesis of the risk of increased health vulnerabilities for Māori under climate change, highlighting the intersecting environmental, social, and governance factors that shape exposure, sensitivity, and adaptive capacity. Evidence of this draws on published literature and Māori-led reports to identify systemic risks, compounding pressures, and key opportunities for strengthening Māori health resilience through Te Tiriti-consistent approaches.

Table 20: Summary table for climate risk and increased health vulnerabilities

Risk description	Māori face increased health risks from climate change due to systemic inequities in housing, healthcare, and infrastructure, along with exclusion from health governance and climate planning. These factors heighten vulnerability to heat, disease, displacement, and distress, particularly for wāhine Māori, disabled Māori, and rural whānau.
Exposure (current)	Māori face overlapping exposure to poor housing, degraded ecosystems, and limited access to safe water and services, particularly in rural and coastal areas.
Exposure (2050)	Likely to worsen due to more frequent heatwaves, food insecurity, and rising disease incidence, especially where health system reform lags.
Exposure (2090)	Severe, High warming could escalate health crises, mental health stress, and infectious disease risks in overcrowded, tikanga misaligned care environments.
Sensitivity	High, due to historical inequities and cultural health determinants, and particularly acute for rangatahi, wāhine Māori, disabled, and rural whānau.
Adaptive capacity	Moderate, present in community-led systems but constrained by underfunding, exclusion from national planning, limited infrastructure support and variable depth of iwi leadership capacity across regions. These disparities, combined with intra-Māori inequality, can mask the vulnerability of the most climate-exposed communities.
Compounding and cascading factors	Health risks amplify food insecurity, caregiving burdens, psychological stress, and breakdowns of cultural and social system, especially when marae/papakāinga are affected.
Socioeconomic trends	Persistent inequality in housing, employment, healthcare access, and iwi service disparities deepen vulnerability and slow recovery.
Climate thresholds and tipping points	Thresholds in housing, healthcare, and carer networks are likely to be crossed repeatedly under hazardous conditions, especially in regions with weak infrastructure.
Interactions with mitigation	If tikanga-based, it can provide co-benefits (e.g., housing upgrades and food resilience); if technocratic or exclusionary, it risks entrenching inequality.
Data gaps	Major. No systematic Māori health-climate focused data collection to facilitate creation and monitoring of appropriate indicators; lack of data on diverse Māori groups such as those with disabilities, those with addictions, young and or rural Māori, a lack of tikanga-based services for Māori.
Confidence level	High in direction and relevance, but moderate in precision due to inadequate and fragmented data systems with limited tracking of Māori-led health responses.

Food insecurity, nutritional decline, and the loss of access to mahinga kai are increasingly intensified by the degradation of ecosystems. Research from the NSC Sustainable Seas Challenge highlights how the decline in key species such as pāua, mussels, and kelp forests is reducing access to nutritious kaimoana, disproportionately affecting coastal whānau who have few alternative food sources (Short et al. 2023; Bulmer et al. 2024). These pressures are not equally distributed: Johnson, Fisher, and Parsons (2022) have underscored how climate vulnerability of wāhine Māori (including reduced access to mahinga kai) is shaped by overlapping factors such as age, class, and household status, affecting exposure to hazards and capacity to respond. These

© New Zealand Institute for Bioeconomy Science Limited (2026)

ecological losses intersect with economic precarity as marine-based enterprises face climate-driven disruptions, contributing to job insecurity and psychosocial stress.

Johnson, Parsons, and Fisher (2023) show that low-income, single, and older Māori women in Kaipara face heavier health burdens because they are left out of adaptation planning while working precarious horticulture jobs. Exclusion means work plans and protections are set without them: longer peak-season hours in heat, more outdoor exposure, chemical contact, lifting without adequate gear, limited shade and water, and no say over transport or break times. Precarious contracts reduce sick leave and clinic access, so heat stress, injuries, and anxiety go untreated. The result is worsening health on top of existing inequities, borne by the very workers who keep local food systems running.

All these ecological and economic pressures exacerbate pre-existing health inequities among Māori, who already face high rates of respiratory, cardiovascular, and metabolic conditions. Climate change is expected to worsen these disparities through increased exposure to heatwaves, poor air and water quality, and stress-related illness. Recent epidemiological evidence from Lai et al. (2024) confirmed that rising daily temperatures are significantly associated with increased child hospital admissions in Aotearoa, signalling a direct health risk from warming that disproportionately affects vulnerable communities. While the study was population-wide, its findings underline the heightened climate sensitivity of groups already facing structural disadvantage, including Māori.

These risks compound an enduring legacy of structural underinvestment and marginalisation within the health system. Cleghorn, Nghiem and Ni Mhurchu (2022) modelled population-wide adoption of diets optimised for health in Aotearoa, and found that these would generate health gains, health system cost savings, and reductions in greenhouse gas emissions. All of these could improve health equity between Māori and non-Māori. Similarly, King et al. (2020) noted that rising temperatures and environmental stressors will aggravate asthma and diabetes. The COVID-19 pandemic underscored how systemic barriers can delay effective responses, yet it also revealed the strength of Māori-led solutions when adequately resourced. Tapsell (2022) has emphasised how Māori health resilience is rooted in relational infrastructure, whānau, marae, and community knowledge; and that those roots are often sidelined in technocratic health planning.

Climate-related displacement, disruption to tikanga, and environmental trauma pose serious risks to mental health. Studies by Waitoki and McLachlan (2022) and Te One and Clifford (2021), have both highlighted the critical role of tino rangatiratanga and collective identity in buffering against psychological harm, particularly during emergencies such as flooding or relocation. Johnson, Parsons, and Fisher (2023) described how Māori women's emotional and mental well-being is degraded by climate-exacerbated economic vulnerability and exclusion from decision-making processes. The effect is to amplify feelings of powerlessness and solastalgia (emotional distress from negatively perceived environmental change). These protective mechanisms are undermined when Māori governance is excluded from adaptation planning (Masters-Awatere, Young, & Graham 2022).

With climate change driving more frequent flooding, damp and damaged homes and crowded emergency shelters increase the risk of waterborne and infectious illness. Evidence for this pattern in Aotearoa is reported by Cassim and Keelan (2023); their NZ study indicates current risks that are likely to grow without housing and emergency-health improvements. Vulnerable Māori groups, including the elderly, disabled, people with limited mobility, and drug users, face compounded precarity during climate events, with disrupted access to services, housing, and medical supplies, reinforcing social exclusion (Ingham et al. 2022, 2023; Blake et al. 2024). Apiti et al. (2023) reported that climate trauma and disconnection from whenua exacerbate solastalgia and mental

© New Zealand Institute for Bioeconomy Science Limited (2026)

health distress, especially when tikanga-based anchors such as mahinga kai and marae are compromised.

Broader structural issues, such as housing, employment, and infrastructure, further entrench climate vulnerability. Māori in rural and remote areas face significantly lower median incomes than the national average, limiting their ability to invest in preparedness, recovery, and adaptation. Rua et al. (2023) found Māori are overrepresented in the precariat, with insecure access to housing, income, and basic services. Climate change is likely to deepen these instabilities. Reliance on Māori women as flexible labour in climate-sensitive commercial horticulture traps them in work that is both physically harmful and financially unstable (Johnson, Parsons & Fisher 2023). This highlights a climate-health feedback loop that is both gendered and racialised.

Simultaneously, marae-based services, which often act as emergency response centres and health providers, are structurally under-resourced and increasingly exposed to climate-related hazards (McMeeking & Savage 2020). Infrastructure failures, especially in rural areas, can sever access to critical health care, compounding risks for isolated whānau (McMeeking & Savage 2020). Food insecurity remains a core issue, as climate pressures reduce mahinga kai availability and increase food costs, all further diminishing the nutritional well-being of Māori communities (Houkamau et al. 2021). Lambert and Mark-Shadbolt (2021) similarly noted that the breakdown of ecological relationships due to environmental degradation undermines both sustenance and whakapapa, weakening collective oranga.

Intersecting health and disability risks further highlight the necessity of inclusive adaptation. Observations of systemic failures during COVID-19 signal impacts for kāpō Māori (i.e. blind and low vision Māori); (see Graham et al. 2021; Masters-Awatere et al. 2024). Kaiwai and Allport (2023), writing for the WAI 2575 Inquiry, detailed the systemic neglect of disabled Māori in health services. Climate emergencies exacerbate these inequities, increasing barriers to care, communication, and tikanga-based support. Without disability-inclusive, Te Tiriti-consistent planning, these communities remain highly vulnerable. The broader findings of the WAI 2575 Inquiry reinforced this point, documenting the Crown's persistent failure to deliver equitable health outcomes for Māori due to governance exclusion, underfunding, and institutional racism. These same failings risk being replicated in climate adaptation unless redressed (Waitangi Tribunal 2023). Sharma et al. (2024) noted that without Māori-led data systems and climate-health infrastructure, disabled Māori are rendered invisible in emergency response planning (Mead et al. 2022).

Recent health crises offer further evidence of systemic failure. Te Poutoko Ora a Kiwa's (TPOAK) review of the COVID-19 Māori Vaccination Programme found significant delays in funding and decision-making pathways, impeding Māori responsiveness (Te Poutoko Ora a Kiwa 2022). The Waitangi Tribunal's *Haumaru* Report (Waitangi Tribunal 2021) also found that the Crown had breached its Te Tiriti obligations by failing to prioritise Māori health protections during the pandemic. These failures underline urgent structural risks in public health governance that, if left unaddressed, will undermine Māori resilience in the face of future climate-driven health emergencies. A shift toward Māori-led, Te Tiriti-consistent climate health governance is essential to remedy past harms, support collective well-being/oranga, and secure intergenerational well-being.

3.7.1 Exposure – current, 2050, and 2090

Māori communities experience higher rates of pre-existing health conditions, such as respiratory illnesses, kidney problems, cardiovascular disease, and diabetes than the rest of the population (Hogarth & Rapata-Hanning 2023). These inequities have been, and still are, shaped by structural determinants, including housing quality, access to healthcare, and environmental degradation.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Climate change is expected to interact with these vulnerabilities in ways that increase Māori exposure to adverse health outcomes (King et al. 2020; McMeeking & Savage 2020; Houkamau et al. 2021; Masters-Awatere 2021). Taiapa et al (2024) and Apiti et al. (2023) both noted that Māori well-being is tightly linked to tikanga and whenua, which are highly climate-sensitive and currently under-protected in health system planning.

Wheeler et al. (2025) identified persistent gaps in cardiovascular disease risk assessment for Māori in primary care, underscoring a baseline vulnerability that is likely to worsen with increased climate-related stressors. Similarly, Mullane et al. (2022) showed that under-resourcing in the diabetes care workforce disproportionately affects Māori and Pacific people, particularly in community and primary health settings. Heaps (2023) reported that upstream social determinants, such as poverty, overcrowded housing, and environmental pollution, significantly drive asthma disparities for Māori, further intensifying climate-related health exposure.

Māori living in flood-prone or coastal areas face direct exposure to hazards that can trigger health-related impacts. For example, marae that double as emergency hubs may be vulnerable to flooding and damage, disrupting community-led welfare services (Bailey 2022). Lambert and Mark-Shadbolt (2021) noted that Māori communities often act as de facto health responders in biosecurity and freshwater crises despite lacking infrastructure support.

Poor housing conditions and limited access to safe drinking water further exacerbate this exposure, especially in rural and low-income communities, where Māori often experience substandard rental housing, overcrowding, and limited access to healthcare. These intersecting exposures are particularly acute in regions like Te Tai Tokerau (Northland), where service withdrawal has followed population decline and government disinvestment (Andersen 2024; Hughes et al. 2021; Johnson, Fisher & Parsons 2022).

Recent analysis by Lai et al. (2024) demonstrated that rising daily temperatures in Aotearoa are linked to increased child hospital admissions. This provides direct epidemiological evidence of how climate exposure can drive acute health impacts, particularly for vulnerable communities lacking robust housing and healthcare access. Su and Wu (2020) reinforced this point by showing in their study that many remote Māori communities live in damp, poorly insulated homes with inadequate ventilation. These conditions will all heighten vulnerability to heat, cold, and respiratory illness under climate pressure.

The experience of COVID-19 has provided insight into systemic barriers Māori face in emergency health contexts. Despite iwi-led initiatives such as the iwi-lead Te Ranga Tupua rapidly establishing dedicated coordination hubs grounded in tikanga Māori (Boulton et al. 2022), delays in funding for Māori-led health responses and a lack of dedicated coordination structures limited the effectiveness of tikanga-based care during the pandemic (Waitangi Tribunal 2021; Te Poutoko Ora a Kiwa 2022).

Internationally and in Aotearoa New Zealand, psychologists have been reporting emotional distress in clients, variously described as ‘eco-anxiety’, ‘eco-paralysis’, ‘climate despair’ or ‘solastalgia’ (see earlier), and all commonly related to environmental change (Thompson 2021; Clinton et al. 2022). Lawrance et al. (2022) and Hayes et al. (2018) emphasised that climate-induced emotional distress is more intense for structurally marginalised populations, especially Indigenous communities, and must be considered a central dimension of exposure.

Responding to the aspects of distress noted above will/should affect future climate-related health emergencies, where the need for timely and equitable health interventions will increase. The success of iwi-led efforts during COVID-19, as documented by Boulton et al. (2022), demonstrated

© New Zealand Institute for Bioeconomy Science Limited (2026)

both the potential and the urgency of resourcing tikanga-based care in future climate-health emergencies. Tapsell (2022) has argued that failing to embed Māori governance in emergency systems replicates colonial health inequities under climate pressure.

By mid-century (under c. 2050, 1.5°C–2°C warming), health exposure is expected to increase due to more frequent heatwaves, increased incidence of waterborne and vector-borne diseases, and rising food insecurity. The degradation of marine ecosystems and the decline of mahinga kai may reduce access to nutritious, relationally important foods, particularly for coastal whānau with limited alternatives (Short et al. 2023; Bulmer et al. 2024). These effects intersect with economic instability, leading to increased stress and mental health strain (Rua et al. 2023; Muncaster et al. 2024). Ingham et al. (2023) noted that Māori respondents in national health surveys frequently report barriers to health access and culturally inappropriate care, factors that amplify exposure during high-stress periods such as climate emergencies.

Projected impacts for 2090 (at 2°C–3.5°C warming) may intensify these exposures, particularly for kaumātua, disabled Māori, and those with chronic health conditions. Climate-driven displacement or managed retreat could disrupt tikanga and increase mental health stress, particularly if relocation processes are not tikanga-based (Te One & Clifford 2021; Waitoki & McLachlan 2022). Crowded housing or emergency shelters could also increase the spread of infectious disease, particularly where infrastructure is weak (Cassim & Keelan 2023). Sharma et al. (2024) suggested that without Māori-controlled planning tools, infrastructure risk is currently underestimated, and response systems will remain misaligned with actual community needs.

Jones et al. (2024) stressed that Māori with lived experience of disability are frequently face erasure in mainstream data and planning systems. This leads to adaptation frameworks that overlook vital support needs during climate-related dislocation or health emergencies. Blake et al. (2024) found that Māori who inject drugs face acute health risks during flood events, including disrupted access to clean water, medication, and shelter, yet they are routinely excluded from disaster planning. Their work demonstrates how stigma compounds climate exposure for already vulnerable groups.

Multiple compounding factors influence exposure in this domain. There is uncertainty around the scale of future health impacts. The focus on iwi and hapū governance in adaptation planning has often overlooked the needs of whānau and individuals, thereby missing critical differences in exposure, such as for kaumātua living alone, Māori with disabilities, or single-parent households. Additionally, it is important to recognise that the governance capabilities among hapū/iwi vary significantly, which may affect their ability to adapt to different challenges. As a result, adaptation processes may not reflect the lived realities of those most vulnerable (Johnson, Fisher & Parsons 2022).

Evidence from the WAI 2575 Inquiry and from health equity research indicates that institutional reform and investment in Māori health governance will be necessary to avoid repeating current gaps in care and service access (Kaiwai & Allport 2023; Waitangi Tribunal 2023). Daly et al. (2024) showed that women in Aotearoa diagnosed with gestational diabetes mellitus face long-term health risks – including renal and cardiovascular disease; and these health risks intersect with a disproportionate exposure of wāhine Māori to climate stressors such as poor housing, food insecurity, and heat exposure.

Both Tait-Wall et al (2022) and Moewaka Barnes et al (2021) have argued that solutions to these vulnerabilities and inequities may lie in a return to Indigenous knowledge systems. Strengthening marae-based health services, backing Māori-led local planning, and investing in fit-for-purpose infrastructure can cut exposure to floods, heat, contamination, and service outages, and lift the

© New Zealand Institute for Bioeconomy Science Limited (2026)

resilience of Māori whānau, marae, and hapū/iwi. Without these steps, climate change will deepen existing inequities and entrench access barriers, especially for Māori in rural, low-income, disabled, or single-parent households, because mainstream adaptation systems often overlook their needs (Johnson, Fisher & Parsons 2022; Kaiwai & Allport 2023).

3.7.2 Sensitivity and adaptive capacity

Māori are highly sensitive to climate-related health risks because of the persistence of structural health inequities across Aotearoa. These include elevated rates of respiratory illness, diabetes, cardiovascular and kidney disease, and mental distress. These conditions are likely to be exacerbated by climate-related hazards such as heatwaves, waterborne disease, degraded air and water quality, and disrupted access to quality living conditions and healthcare services (King et al. 2020; McMeeking & Savage 2020; Houkamau et al. 2021; Masters-Awatere 2021; Whitehead & Walker 2021). Apiti et al. (2023) noted that Māori health and resilience are tikanga-based and can be undermined when adaptation efforts fail to engage with whenua, karakia, and maramataka as protective health mechanisms. Additionally, intersecting identities such as gender, age, location, and income affect the extent to which these mechanisms are protective or accessible (Johnson, Fisher & Parsons 2022).

Lai et al. (2024) have reported that rising daily temperatures already contribute to increased hospitalisations, especially among children, highlighting the heightened climate sensitivity of Māori communities with limited access to adequate housing and healthcare. Wheeler et al. (2025) further demonstrated significant gaps in managing cardiovascular disease risk in primary care for Māori and Pacific people, reinforcing the structural inequities that amplify health sensitivity under climate stress. Heaps (2023) identified substandard housing, exposure to pollutants, and institutional racism as key upstream factors contributing to disproportionately high asthma rates among Māori, highlighting how structural determinants intersect with climate drivers like air quality to worsen health outcomes. Mullane et al. (2022) added information showing that the health workforce supporting Māori and Pacific peoples with diabetes is overstretched, limiting adaptive health responses at the community level. Blake et al. (2022) showed that Māori face greater disruption in the aftermath of disasters due to barriers in housing, finance, and cultural continuity, and that relocation decisions often occur under distress, without support that aligns with tikanga or place-based attachments. All these factors increase mental distress and disrupt health service continuity.

The sensitivity of Māori to these risks is compounded by material conditions such as poor housing quality, household crowding, and limited access to health infrastructure, especially in rural or flood-prone areas (Hughes et al. 2021; Andersen 2024). Lower median incomes in many rural Māori communities further reduce their ability to invest in adaptation or recovery, weakening household and community resilience to climate-related events (van Meijl 2020).

Ingham et al. (2023) also identified material deprivation, housing instability, and transport barriers as key drivers of generally reduced healthcare access for Māori, further compounding community-level sensitivity. Su and Wu (2020) showed that many remote Māori communities live in damp, cold, and overcrowded housing with poor ventilation and limited insulation, directly increasing vulnerability to respiratory illness, thermal stress, and mould exposure, climate-sensitive risks that are further exacerbated by energy poverty. At the same time, the emergence of a growing Māori middle class, often urbanised and disconnected from rural papakāinga, has created intra-Māori economic disparities that mirror broader patterns of inequality in Aotearoa. This uneven distribution of material, institutional, and intellectual resources can give a false impression of collective Māori resilience, while leaving the most climate-exposed communities under-supported (van Meijl, 2020).

© New Zealand Institute for Bioeconomy Science Limited (2026)

The degradation of mahinga kai and coastal ecosystems reduces access to nutritious, relationally important foods, contributing to food insecurity and declining oranga (well-being), particularly among coastal households where mahinga kai decline overlaps with economic marginalisation and household caregiving responsibilities (Johnson, Fisher & Parsons 2022; Short et al. 2023; Bulmer et al. 2024). These effects intersect with socio-economic stressors, increasing psychosocial vulnerability, particularly for rangatahi, kaumātua, and those already facing exclusion from housing, employment, and public services (Cram 2021; Bailey 2022; Paul & Ratana 2022; Kawharu 2023; Ratana 2023; Rua et al. 2023; Andersen 2024). Lambert and Mark-Shadbolt (2021) also noted that spiritual and emotional health is threatened when taonga species decline, severing the relational links that sustain hapū/iwi well-being.

Some Māori with disabilities and drug addictions experience layered vulnerabilities, including barriers to accessible services and limited inclusion in emergency planning processes, as noted in the Wai 2575 Inquiry (Kaiwai & Allport 2023; Blake et al. 2024). These risks may be compounded during climate events if health and adaptation policies do not actively uphold Te Tiriti obligations and promote inclusive design.

Marae and papakāinga, which serve as centres for emergency support and hapū/iwi well-being, are increasingly exposed to climate hazards yet are often structurally under-resourced (Munro 2021; Bailey 2022). These facilities are integral to community resilience, but when they are damaged or inaccessible, the capacity of whānau to organise mutual care is significantly reduced (Cram 2021). However, research suggests that marae resilience varies widely depending on governance capacity, funding access, and connections to youth and kaimahi (workers) (Johnson, Fisher & Parsons 2022).

Lawrance et al. (2022) and Hayes et al. (2018) have emphasised that the psychological toll of climate change, manifested through eco-anxiety, solastalgia, and collective grief, is more severe in marginalised populations, including Indigenous groups, further increasing sensitivity where cultural identity is entwined with ecosystem health.

Whānau Māori have adaptive strengths, but these vary and often happen within households in ways that iwi-focused adaptation models tend to miss (Johnson, Fisher & Parsons 2022). Whānau, hapū, and iwi-led health initiatives have been highly effective in past crises, such as New Zealand's COVID-19 response, but these efforts often occurred without timely state support (Graham et al 2021; Waitangi Tribunal 2021; Te Poutoko Ora a Kiwa 2022; Waitoki & McLachlan 2022). Examples of adaptive leadership included the rapid establishment of marae-based testing and vaccination sites, tikanga-based care networks, and mutual aid systems grounded in manaakitanga and mahi aroha (Cram 2021; Cassim & Keelan 2023).

All the initiatives mentioned in the preceding paragraph highlight the potential of Māori-led systems, but these systems remain structurally underfunded and are not yet embedded in national climate or health resilience planning (Kaiwai & Allport 2023; Masters-Awatere, Young & Graham 2022; Rout et al. 2025). Sharma et al. (2024) cautioned that Māori-led infrastructure, digital or physical, must be adequately resourced to support long-term resilience in the face of compounding environmental shocks.

Jones et al. (2024) showed that Māori with lived experience of disability are leading new frameworks for self-determination, but are still excluded from most adaptation planning, which limits the broader reach of these adaptive innovations. Ingham et al. (2023) further emphasised that existing national health surveys often fail to capture disability-specific data, limiting the precision of adaptation planning for disabled Māori.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Uncertainty in this risk is moderate. While climate-health pathways are well recognised, there is a lack of disaggregated Māori health data in the context of climate exposure, and limited modelling that integrates structural determinants such as housing and food systems into health forecasts. This limits precision in planning and response. Ingham et al. (2023) advocated for culturally grounded, Māori-led health survey methods as a necessary step to overcome current data limitations and ensure inclusive, reliable health indicators for planning.

3.7.3 Compounding and cascading factors

Māori health vulnerabilities are shaped by a range of intersecting risks that climate change is likely to intensify, many of which are affected by overlapping factors such as gender, disability, age, and geographic isolation. All these risks and factors shape how Māori individuals and households are affected by cascading impacts (Johnson, Fisher & Parsons 2022). Pre-existing inequities in housing, access to healthcare, food security, and infrastructure can place some Māori communities in a position of elevated baseline sensitivity than the New Zealand population overall (King et al. 2020; Houkamau et al. 2021; Andersen 2024). Hogarth and Rapata-Hanning (2023) reinforced this view by documenting the elevated prevalence of non-communicable diseases (NCDs) among Māori, such as asthma, diabetes, cardiovascular, and kidney diseases, intensifying health risks during climate-related events. Mullane et al. (2022) further argued that workforce limitations in diabetes care services for Māori and Pacific peoples reduce health system adaptability during cascading disruptions.

Climate-related events such as rising temperatures, flooding, and extreme weather can disrupt access to medical care, clean water, and secure housing, particularly in rural and coastal areas where many Māori communities live (McMeeking & Savage 2020; Hughes et al. 2021; Lai et al. 2024). Lai et al. (2024) provided epidemiological evidence that daily temperature increases in Aotearoa already contribute to higher child hospital admission rates, illustrating a direct climate-health link. These acute events can exacerbate chronic conditions and place additional pressure on under-resourced services such as marae-based support networks and local clinics (Bailey, 2022; Kawharu 2023). Su and Wu (2020) also noted that poor housing quality, including dampness, poor ventilation, and overcrowding in rural Māori housing, further heightens vulnerability to respiratory illness, heat stress, and illness transmission when health infrastructure is disrupted.

Climate-driven degradation of mahinga kai and coastal ecosystems (warming seas, sedimentation) is constraining access to culturally significant, nutritious kai, with knock-on effects for oranga and nutrition (Short et al. 2023; Bulmer et al. 2024). This intersects with identity and wellbeing, undermining hapū/iwi ties and intergenerational knowledge, and adding mental health strain (Apiti et al. 2023), while practical and access barriers limit effective responses (Ingham et al. 2023). Related clinical risks are heightened for wāhine Māori with prior gestational diabetes, whose long-term cardiovascular and renal risks compound under food insecurity and extreme heat (Daly et al. 2024).

High rates among Māori of non-communicable diseases such as asthma, cancer, cardiovascular and kidney disease, and diabetes are well documented. These health inequities magnify the impacts of climate change. Heaps (2023) linked these conditions to environmental exposure and upstream structural drivers such as institutional racism, low-quality housing, and pollution. Su and Wu (2020) reinforced this view by showing how substandard housing and thermal inefficiency directly compound climate-health vulnerabilities.

Illness, displacement, and reduced access to services during climate events can also affect mental health and psychosocial stability, especially for rangatahi, kaumātua, and those experiencing

© New Zealand Institute for Bioeconomy Science Limited (2026)

housing or employment precarity (Paul & Ratana 2022; Ratana 2023; Rua et al. 2023). Johnson, Fisher and Parsons (2022) also argued that wāhine Māori who shoulder caregiving responsibilities and often experience compounding stress from service breakdowns, housing insecurity, and social marginalisation during climate events are at risk. When Māori infrastructure, such as marae and papakāinga, are compromised by flooding or coastal erosion, the health and social care functions they provide often collapse at the household scale under sustained climate pressures, especially when whānau lack institutional support or intergenerational capacity to lead adaptation (Johnson, Fisher & Parsons 2022).

When Māori infrastructure, such as marae and papakāinga, are compromised by flooding or coastal erosion, the health and social care functions they perform are likely to be interrupted, leading to cascading impacts on oranga and social cohesion (Cram 2021; Munro 2021). Legal and institutional frameworks that exclude Māori leadership in health and emergency planning then further reduce the ability to respond effectively during crises (Kaiwai & Allport 2023; Rout et al. 2025). Tapsell (2022) and Erueti et al. (2023) have argued that without structural support for Māori-led health governance, repeated exclusion may lead to institutional burnout and the loss of tikanga-based care systems.

For Māori with addictions or disabilities, the lack of accessible and tikanga-based planning may exacerbate these vulnerabilities (Blake et al. 2022, 2024; Kaiwai & Allport 2023). In these ways, health is not only an outcome of other compounding risks, but also a factor that amplifies the difficulty of recovery and adaptation, especially when governance settings are not inclusive or Te Tiriti-consistent. Sharma et al. (2024) noted that the absence of Māori-controlled digital health and disaster response infrastructure further compounds delays in equitable service delivery. As noted earlier, Blake et al. (2024) showed that exclusion from health systems is especially acute for Māori with drug addictions, underscoring how stigma and criminalisation intersect with climate risk.

3.7.4 Socioeconomic trends that may exacerbate the risk

Key socioeconomic factors that may exacerbate Māori health vulnerabilities are the persistence of structural inequality across housing, employment, and health, compounded by systemic and policy inequities. Māori populations in some regions continue to experience higher rates of housing insecurity and overcrowding, which increases susceptibility to heat stress, infectious diseases, and respiratory illnesses under climate stressors such as flooding or extreme heat (Hughes et al. 2021; Bailey 2022; Harrington et al. 2023; Andersen 2024). In many areas, these housing-related risks intersect with ongoing underinvestment in Māori-specific health infrastructure and with limited availability of tikanga-based, accessible care, especially for Māori with disabilities or those reliant on marae-based support systems (Waitangi Tribunal 2021; Kaiwai & Allport 2023). Apiti et al. (2023) and the Tai-o-Rongo Research Collective (2024) noted that these systemic gaps in housing and health infrastructure are compounded by planning processes that fail to accommodate either tikanga Māori or their local knowledge of resilience.

At the same time as facing the inequities mentioned above, current labour market trends affecting Māori, particularly the disproportional presentation in insecure, low-paid, and climate-exposed work, may constrain financial resilience and the ability to prepare for or recover from health-related climate shocks (Paul & Ratana 2022; Rua et al. 2023). Barnes et al. (2022) showed that Māori employed in lower-skilled, physically demanding occupations experience elevated rates of ischaemic heart disease, reinforcing how occupational stratification and exposure to high-risk working conditions deepen baseline health vulnerability. This vulnerability extends to seasonal horticulture work where wāhine Māori face intersecting risks from race, age, health status, and dependency on welfare-linked labour schemes (Johnson, Fisher & Parsons 2022; Johnson, Parsons & Fisher 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

In many communities, adaptation relies on informal care systems, such as marae or whānau networks, which are increasingly overstretched during emergencies (Cram 2021). Lambert and Mark-Shadbolt (2021) have stressed that in such conditions, tikanga-based support systems are vital for Māori well-being but remain structurally unsupported by our current welfare and health system. Lisipeki et al. (2023) further demonstrated that Māori men recovering from cardiac events experience persistent financial insecurity, which undermines their recovery, heightens stress, and limits access to basic care and transport. This all highlights how economic hardship compounds health impacts in crisis contexts.

Research also highlights growing intra-Māori economic disparities. There are a small number of iwi-based elites benefiting from post-settlement asset control. However, the same time, many rural Māori remain economically marginalised and underserved by government and iwi institutions (Johnson, Fisher & Parsons 2022). Without systemic changes in how health, housing, and income security are supported for Māori under climate pressure, these socioeconomic conditions may compound the impacts of extreme events and delay recovery, deepening intergenerational health inequities.

3.7.5 Climate thresholds and tipping points

The severity of health-related climate risks for Māori may escalate once physical, service, and social thresholds are exceeded. Biophysical thresholds include temperatures beyond which existing housing stock and public health infrastructure cannot prevent heat-related illness or respiratory impacts, especially in overcrowded or poorly insulated homes (Hughes et al. 2021; Andersen 2024). With projected temperature increases of up to 3.25°C and more than 70 hot days annually in regions like Dargaville, risks of dehydration, skin cancer, and respiratory distress are expected to increase, particularly for wāhine Māori working in the outdoor sectors (Johnson, Parsons & Fisher 2023). Su and Wu (2020) reported that many Māori households, especially in remote areas, experience poor housing insulation and overcrowding, increasing the likelihood of heat stress and illness during hot periods. Lai et al. (2024) have also provided epidemiological evidence that rising daily temperatures already contribute to increased hospital admissions, particularly among Māori children (Tamariki Māori).

Infrastructure thresholds, such as flood damage to transport routes or rural clinics, may restrict access to healthcare, clean water, or food, particularly in isolated communities (Bailey 2022; Te Poutoko Ora a Kiwa 2022). Institutional thresholds may also be breached when Māori health services and marae-based care networks become overwhelmed by repeated emergencies. This is especially likely if: i) mainstream systems do not recognise or support Māori-specific delivery models (Cram 2021; Kaiwai & Allport 2023); ii) the marae and Māori-based health (hauora) services under stress rely on unpaid or volunteer labour; and iii) where whānau networks are already strained by caregiving responsibilities, housing pressure, or the erosion of intergenerational knowledge transmission (Johnson, Fisher & Parsons 2022; Cram 2021). Sharma et al. (2024) cautioned that the absence of Māori-led digital infrastructure, planning tools, and service pathways may increase the likelihood that health thresholds will be crossed without early warning or tikanga-based mitigation. Ingham et al. (2023) also thought that barriers to tikanga-safe, accessible healthcare, especially in rural or economically marginalised communities, constrained Māori's ability to respond before critical thresholds are reached.

Epidemiological vulnerabilities further elevate the risk of crossing climate thresholds for Māori communities. High rates of non-communicable diseases such as cardiovascular illness, asthma, diabetes, and renal disease create a baseline of health sensitivity higher than the general New Zealand population that reduces tolerance to climate-related stress (Heaps 2023; Hogarth & Rapata-Hanning 2023). As temperatures rise and extreme events become more frequent, Māori

© New Zealand Institute for Bioeconomy Science Limited (2026)

with pre-existing conditions are more likely to require acute care under conditions where housing, transport, and healthcare systems may already be compromised (Su & Wu 2020; Lai et al. 2024). New Zealand evidence shows that when ambient daily temperatures rise, especially above ~24.1 °C, under-five hospital admissions increase, with Māori children more affected (Lai et al. 2024). Cardiovascular and renal conditions, especially those affecting wāhine Māori with histories of gestational diabetes, are likely to worsen under heat stress and food insecurity, amplifying long-term health burdens if recovery systems fail to respond equitably (Daly et al. 2024; Wheeler et al. 2025).

Threshold breaches are also more likely when healthcare infrastructure is under-resourced or inaccessible. Barriers such as transport costs, culturally inappropriate care, and lack of service availability disproportionately affect Māori living in remote or economically marginalised regions (Mullane et al. 2022; Ingham et al. 2023). Disabled Māori and Māori with addictions face additional exclusion if services are not designed with accessibility or tikanga in mind, leaving them vulnerable to life-threatening gaps in support during crises (Blake et al. 2024; Jones et al. 2024). Mental health tipping points are a critical concern, particularly when displacement or sustained service disruption compounds trauma, grief, and the erosion of cultural practices. These patterns have been identified in general literature on solastalgia and climate grief (Hayes et al. 2018; Lawrance et al. 2022) and in Aotearoa-specific contexts such as post-disaster relocation (Blake et al. 2022). Despite these risks, current adaptation policies often fail to integrate Māori epidemiological data or infrastructure needs, increasing the likelihood that health system thresholds will be silently crossed without effective mitigation (Pourzand et al. 2023; Sharma et al. 2024).

Community care can reach a tipping point when climate pressures are added to existing health burdens. If marae, whānau, and kaupapa Māori services continue to fill gaps without sufficient resources or decision-making authority, burnout and loss of tikanga can result (Kawharu 2023; Rua et al. 2023). Exclusion of disabled Māori or those with chronic conditions from tikanga-based, climate-resilient care pathways risks irreversible harm (Kaiwai & Allport 2023). Displacement and disrupted tikanga also drive lasting mental health impacts, especially when relationships to whenua and maramataka are broken (Apiti et al. 2023).

3.7.6 Possible interactions with climate mitigation actions

Climate mitigation actions can either reduce or exacerbate Māori health vulnerabilities, depending on whether they address the structural determinants of health, such as housing, transportation, and energy systems. Climate change itself, and intra-Māori disparities may also affect how mitigation is delivered and therefore its effects.

i) Mitigation initiatives that improve home energy efficiency, support low-emission heating, and upgrade infrastructure in rural areas may yield significant co-benefits for respiratory health, thermal comfort, and energy security, particularly for Māori whānau in low-quality or crowded housing (Hughes et al. 2021; Andersen 2024). Su and Wu (2020) have provided direct evidence that improving housing insulation and ventilation can reduce health risks in remote Māori communities. Heaps (2023) also linked energy inefficiency to high asthma rates, reinforcing the public health gains of targeted retrofitting programmes. Similarly, active transport and sustainable urban design could improve physical well-being if such initiatives are inclusive of Māori communities and accessible across urban–rural divides (Rua et al. 2023). Apiti et al. (2023) have emphasised that when Māori-led food systems, energy systems, and housing strategies are aligned with tikanga, mitigation efforts can simultaneously advance health equity and hapū/iwi well-being.

ii) If not intentionally designed to address the existing structural inequities faced by Māori, climate mitigation actions are likely to entrench or exacerbate health disparities, particularly through

© New Zealand Institute for Bioeconomy Science Limited (2026)

unequal access to incentives, infrastructure upgrades, or environmental interventions. This risk is already evident in water infrastructure and horticultural expansion projects, where Māori communities have reported increased precarity and exclusion from decision making (Johnson, Fisher & Parsons 2022; Johnson, Parsons & Fisher 2023). For instance, intensifying urban housing to reduce emissions may not meet Māori housing aspirations if it disregards intergenerational or collective living models (Berghan 2021). Jones et al. (2024) has also demonstrated that disabled Māori are frequently excluded from infrastructure planning, thereby limiting their access to physical spaces and the co-benefits of mitigation. Financial incentives for emissions-reduction technologies (e.g. use of EVs or solar) may disproportionately benefit high-income households, potentially widening health-related disparities in air quality, energy access, or mobility. Ingham et al. (2023) also noted that cost, digital exclusion, and transport challenges often prevent Māori from accessing new technologies or healthcare innovations.

Equity-focused mitigation is essential. Māori already face higher rates of asthma, diabetes, cardiovascular disease, and mental distress shaped by housing, nutrition, and care access (Hogarth & Rapata-Hanning 2023). Persistent gaps in cardiovascular and diabetes care mean mitigation co-benefits will be missed without better access, especially for wāhine Māori with prior gestational diabetes (Wheeler et al. 2025; Mullane et al. 2022; Daly et al. 2024). Without inclusive, tailored measures, mitigation may entrench rather than ease these inequities.

Mitigation/adaptation can support mental wellbeing, less stress, and stronger ties to whenua, but these gains shrink when Māori are displaced, sidelined in planning, or cut off from whenua; disruptions to relational ties to whenua can trigger climate-related distress (Lawrance et al. 2022; Hayes et al. 2018). Māori with addictions or layered vulnerabilities are often missed without intentional, inclusive design (Blake et al. 2024). A Te Tiriti-consistent, health-integrated, equity-focused approach is needed to avoid entrenching harm (Pourzand et al., 2023).

iii) Climate change itself may make the delivery of mitigation harder, especially when repeated hazard events disrupt health infrastructure or reduce community capacity to participate in planning. Blake et al. (2022) noted that repeated relocation and trauma following disasters erodes the ability of communities to engage meaningfully in future resilience initiatives. Sharma et al. (2024) found that Māori exclusion from climate tech development and data governance may limit their access to the co-benefits of low-emissions investment unless mitigation systems are designed with Te Tiriti partnerships. Integrating Māori public health leadership into mitigation policy and ensuring kaupapa Māori models are recognised in resilience planning will be essential for delivering dual benefits for emissions reduction and Māori health equity (Cram 2021; Kaiwai & Allport 2023).

iv) Māori exclusion from mitigation benefits can also be also shaped by intra-Māori inequality, where iwi-led governance or asset control may not trickle down to low-income or rural whānau, particularly those disconnected from formal iwi structures (Johnson, Fisher & Parsons 2022).

3.7.7 Data gaps

There are significant gaps in understanding how climate change affects Māori health outcomes across exposure, sensitivity, and adaptive capacity. While some national health data sets disaggregate by ethnicity, they often fail to capture climate-related drivers, such as heat exposure, vector-borne disease risk, or housing-related illnesses, in the context of extreme weather (Hughes et al. 2021; Andersen 2024). Data on access to tikanga-based and climate-resilient health infrastructure remains fragmented, with no consistent monitoring of rural Māori-specific infrastructure, including papakāinga-based clinics, hauora units, or marae emergency networks (Johnson, Fisher & Parsons 2022; Tai-o-Rongo Research Collective 2024).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Sensitivity has not been/is not consistently measured, particularly for high-risk populations such as some Māori with disabilities, kaumātua, and those in insecure housing or experiencing rural isolation (Waitangi Tribunal 2021; Tane et al. 2022; Kaiwai & Allport 2023). There are no formal indicators for measuring maramataka-aligned well-being, climate-distress, or relational health disruptions, despite their significance in Māori communities (Cram 2021; Johnson, Fisher & Parsons 2022; Apiti et al. 2023). Adaptive capacity data is also limited; while community-led health responses are well documented (e.g. during COVID-19), there is no systematic assessment of Māori health system readiness for climate impacts or tracking of Māori involvement in national health resilience planning. Furthermore, there is no national integration of kaupapa Māori evaluation models or mātauranga Māori-based health frameworks into climate-health surveillance systems (Cram 2021; Johnson, Fisher & Parsons 2022). Sharma et al. (2024) and Kukutai (2024) have both highlighted that the absence of Māori-governed data systems, particularly in environmental and biodiversity contexts, limits equitable access to and control over decision-relevant information.

3.7.8 Confidence level

The overall confidence in the direction and significance of the risk is high, with strong agreement across health equity, Māori well-being, and emergency response literature (King et al. 2020; Cram 2021; Rua et al. 2023). There is consistent recognition in the literature we analysed that Māori face elevated health vulnerability due to structural inequalities and that climate change will likely intensify these burdens. However, confidence in exposure-specific evidence is moderate due to a lack of climate-health surveillance tailored to Māori contexts. The absence of dedicated monitoring systems for Māori health governance, funding, or infrastructure investment readiness limits confidence in understanding adaptive capacity (Walter et al. 2021; Kukutai et al. 2024).

The qualitative and community-based evidence base around the risk is strong and thematically aligned (especially that concerning marae-based responses, wāhine-led care networks, and tikanga-based climate-health indicators that remain largely unrecognised in institutional frameworks [Johnson, Fisher & Parson 2022; Apiti et al. 2023). However, the lack of integrated health–climate data sets probably results in a systemic underestimation of the scale and complexity of Māori health risks under climate change, and the continued exclusion of kaupapa Māori models and Māori-governed data systems from national resilience planning tools and metrics (Cram 2021; Johnson, Fisher & Parsons 2022; Sharma et al. 2024). Apiti et al. (2023) and the Tai-o-Rongo Research Collective (2024) have emphasised the centrality of Māori concepts of well-being, such as oranga, wairua; and, of maramataka, in shaping community responses to environmental change. However, these frameworks remain largely absent from national climate-health policy.

3.7.9 Risk severity summary

Table 21 presents the risk severity criteria for increased health vulnerabilities across four levels of risk, from minor to extreme. It draws on published literature to assess how structural health inequities, climate exposure, and exclusion from health and adaptation governance may compound over time. The risk severity criteria were used to determine the risk severity scores under different climate scenarios. We utilised the Commission's exemplar (see Appendix 2) and adapted it for each risk in the te ao Māori domain.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 21: Increased health vulnerabilities risk severity criteria

Attribute	Minor	Moderate	Major	Extreme
Overarching	• Localised health effects related to seasonal exposure or extreme events. • Community support systems remain functional. • Tikanga-based care maintained in most regions.	• Regional stress on Māori health systems and Māori infrastructure. • Food insecurity and mental health distress rise. • Adaptation access varies across rohe.	• Widespread breakdown of marae-based and tikanga-aligned care. • Chronic conditions worsen. • Māori mental health crisis deepens.	• Systemic collapse of Māori health equity. • Tikanga-based responses absent. • Institutional trust and service legitimacy eroded.
Extent, duration and frequency of likely impacts	• Temporary increase in respiratory illness or heat stress. • Healthcare systems and marae-based services cope adequately. • Disruption limited to single events.	• Cyclical health disruptions linked to climate patterns. • Increased infectious disease and chronic illness burden. • Whānau resilience strained but intact.	• Frequent loss of service access and increased hospitalisation. • Repeated displacement and infrastructure failure. • Persistent food, water, and care insecurity.	• Unrecoverable displacement from whenua and care systems. • Intergenerational trauma entrenched. • Ecosystem loss permanently undermines oranga.
Ability to recover from likely impacts	• Whānau and marae-led responses restore wellbeing. • Some state support received. • Informal care networks function effectively.	• Partial recovery with community initiative. • Structural health gaps slow positive health outcomes. • Uneven iwi capacity results in variable outcomes.	• Recovery requires national Māori health reform. • Whānau care networks near exhaustion. • Funding gaps hinder regional responses.	• Recovery impossible without constitutional transformation. • Māori health sovereignty non-existent in policy. • Climate trauma becomes chronic.
Likely equity impacts	• Procedural barriers visible but not entrenched. • No systemic exclusion from services. • Tikanga-based support accessible in most cases.	• Exclusion of disabled Māori or remote communities persists. • Wāhine and rangatahi Māori face layered burdens. • Intra-Māori inequality becomes visible.	• Māori health needs sidelined in mitigation policy. • Disabled and Māori with addictions are disproportionately excluded. • Māori women are overburdened and unsupported.	• Māori systematically excluded from national health infrastructure. • Generational inequity locked in. • Governance paralysis in emergencies.
Likely impacts on te ao Māori	• Minimal erosion of tikanga-led health responses. • Tikanga and place-based care still widely practised. • Identity and oranga remain strong.	• Decline in hauora and relational health. • Some tikanga-based services under pressure. • Intergenerational transmission of care practices weakening.	• Collapse in whānau cohesion and environmental health ties. • Whenua-based practices lost in some rohe. • Tikanga-based health systems marginalised.	• Wairua and identity fractured. • Taonga species disappear. • Māori wel-lbeing metrics no longer viable.

© New Zealand Institute for Bioeconomy Science Limited (2026)

The following narrative (summarised in Table 22) sets the projected severity of increased health vulnerabilities for Māori under different warming scenarios using the Commission's scoring template (Appendix 3). Baseline sensitivity is high due to housing, income, food access, and system barriers, felt most by wāhine Māori, disabled Māori, and remote communities (Johnson, Fisher & Parsons, 2022; Kaiwai & Allport 2023; Ingham et al. 2023; Jones et al. 2024). Māori are over-represented in climate-sensitive conditions, and care gaps persist (Hogarth & Rapata-Hanning 2023; Wheeler et al. 2025; Mullane et al. 2022; Daly et al. 2024). Heat is already affecting admissions of tamariki Māori (Lai et al. 2024).

By mid-century (1.5°–2.0°C): Rising heat, waterborne disease, and service disruption intensify risks, especially in rural/overcrowded housing and for those with existing conditions; loss of marae-based health supports, and climate-distress are evident (Apiti et al. 2023; Lawrance et al. 2022; Hayes et al. 2018).

By the end of the century (2.5°–3.5°C): Repeated events strain Māori-led health systems, deepen psychosocial harm, and widen disparities where reform and investment lag or where Māori are excluded from emergency planning and infrastructure decisions (Blake et al. 2022, 2024; Tapsell 2022; Pourzand et al. 2023).

The increased vulnerabilities of Māori health risk rise with higher temperatures but also depend on health-system reform and investment in Māori-led resilience. Uncertainty arises from the limited availability of Māori-disaggregated climate-health data and the weak integration of Māori indicators into planning (Ingham et al. 2023). Without embedding Māori governance, monitoring, and data sovereignty, critical risks are underestimated, and responses underperform (Lambert & Mark-Shadbolt 2021; Sharma et al. 2024).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 22: Risk severity scores under different climate scenarios for increased health vulnerabilities

Risk	Present Day	2050	2090 – GWL 2	2090 – GWL 3–3.5
Risk severity	**Its current impact/consequence level**	**Its likely impact/consequence level by mid-century (2050)**	**Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario**	**Its likely impact/consequence level by the end of the century (2090) under a high climate impact scenario**
	Moderate	**Major**	**Major**	**Extreme**
Increased health vulnerabilities	Māori health vulnerability is elevated due to existing chronic conditions, poor housing, and uneven access to culturally safe care. However, strong whānau and marae-based systems provide some buffering capacity in many rohe.	Climate-related health burdens intensify for Māori, particularly in rural and overcrowded housing. Rising temperatures, infectious disease risks, solastalgia, and declining access to marae-based care systems affect well-being. Regional disparities worsen where health reforms lag or infrastructure remains poor.	Māori-led health systems are increasingly strained by repeated climate events, widening mental health impacts and chronic illness disparities. The exclusion of Māori frameworks and data governance undermines effective adaptation and may entrench health system fragmentation.	Compounding stress from frequent disasters leads to system overload, institutional burnout, and intergenerational harm. In the absence of Māori-led planning and sustained investment, health governance may fail to meet Māori needs, with risks becoming systemic and near-irreversible.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4 Part 2: Policy readiness

This section looks at how current and planned actions to adapt will help address the main climate change risks faced by Māori. It will summarise the key policies from the Ministry for the Environment alongside the evidence used in this assessment.

4.1 Outline of Pt 2 approach, structure and methods

We will begin with looking at the Government's climate strategy, which sets the overarching direction for resilience, risk reduction and equitable outcomes (Ministry for the Environment 2024). We will then draw on the Government's proposed national adaptation framework as the organising platform for roles, duties and funding (Ministry for the Environment 2025a), and on active Resource Management reform signals, including consultation on updating national direction (Ministry for the Environment 2025b). We will assess the consenting pathway changes introduced by the Fast-track Approvals Act 2024 (as discussed in Ministry for the Environment 2025c) and its process guidance (Ministry for the Environment 2025d). We will locate these within the Government's climate-change work programme (Ministry for the Environment 2025e), the accompanying independent adaptation report (Ministry for the Environment 2025f), and the detailed "proposed approach" for the framework (Ministry for the Environment 2025g). We will also note the latest Resource Management reform update (Ministry for the Environment 2025h).

Read together with local-government policy instruments (e.g., Whaitua and coastal plans), and with the research and pilot programmes cited throughout this report, this policy set provides the basis for our coverage, readiness, and shortfall analysis for the Ngā mea hirahira o te ao Māori domain.

For each Ngā mea hirahira o te ao Māori domain risk, our team rated three dimensions: policy coverage, readiness to implement/deliver, and policy shortfall, drawing only on policies, plans, and actions that are currently in place or active over the next 6 years (see Table 23). The evidence base for the scores is the set of citations compiled in the NCCRA policy-readiness templates (see Appendix 3) and interpreted in conjunction with the risk-severity assessments from Part 1 to determine whether levers are direct, indirect, or enabling, whether Te Tiriti commitments and Māori-led or co-designed responses are explicit, and whether funding, mandates, roles, and capabilities are sufficiently clear to deliver.

Our scoring (rating) was comparative across risks (i.e. not precision scoring); and where a judgement sat between two ratings, the more conservative (lower) rating was chosen and explained in narrative notes (applying table 23's four-category scale: No significant gaps, Moderate gaps, Significant gaps, Insufficient, for coverage and readiness, and the shortfall gradations, minor, moderate, major, extreme). Missing legal basis or funding was treated as a strong signal of a coverage or delivery gap. If an overall score was uncertain, we leaned on the shortfall judgement and document the rationale.

Each dimension was then assigned a rating using standard criteria. For coverage and delivery, we assessed whether policies clearly address the risk with mandates, resourcing, capable institutions, and active delivery ("No significant gaps", "Moderate gaps", "Significant gaps", "Insufficient"). For policy shortfall, we rated Minor/Moderate/Major/Extreme by how much risk would remain even if all current policies were fully implemented, from Minor (only minimal residual risk), Moderate (some residual exposure or slow uptake), Major (large parts of the risk still unaddressed with major impacts), to Extreme (implementation would not meaningfully reduce core risk).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Every score had to include an analysis that justifies the rating, referencing which drivers of risk were reduced and where residual exposure persisted/persists, especially for iwi/Māori and whenua Māori. Draft scores then underwent expert review in calibration workshops: the authors tested consistency across risks and paid particular attention to Te Tiriti-consistency (counted only with explicit inclusion, co-design, or legal recognition). Disputed ratings were resolved by consensus, with any borderline calls kept conservative and the final overall score confirmed in the workshop summary.

We present our comparative assessment of policy readiness across all risks using three dimensions in Table 24. The dimensions are: policy coverage, readiness to implement/deliver, and policy shortfall, with each rated on a four-point scale (No significant gaps, Moderate gaps, Significant gaps, Insufficient). Scores were based solely on policies, plans, and actions currently in force or funded for delivery within the next six years (proposals are noted but do not impact ratings). Overall, most risks sit at Significant gaps or Insufficient: Loss of access to taonga species, Damage to Māori infrastructure, Disruptions to tikanga and hapū/iwi identity, Loss of Indigenous knowledge systems, and Legal exclusion and governance failure were assessed as Insufficient overall; Economic losses in primary industries and Increased health vulnerabilities were assessed as Significant gaps overall.

The seven subsequent sections (4.2–4.8) show how we derived each score for policy coverage, readiness to deliver, and policy shortfall. For each risk, we identify the mix of direct, indirect, and enabling levers and assess whether mandates, roles, funding, and capability are sufficient to deliver the stated actions that reduce that specific Māori domain risk (readiness). We then state the policy shortfall, i.e., the residual risk that would remain even if current policies were fully implemented, and explain what drives that gap (e.g., limits of scope, reach, or uptake). Note: these explanations are largely presented in the present tense.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 23: Policy readiness criteria (based on different dimensions) – used to evaluate the likely policy readiness for risk

	No significant gaps	Moderate gaps	Significant gaps	Insufficient
Policy rating (all domains)	Policy coverage The risk is well covered, and no significant gaps in policy/action remain. Policies respond well to the risk. Risk is clearly addressed in one or more policies and/or plans (national, local, etc.) with direct actions. Readiness to implement/deliver Policies and plans have clear mandates, resourcing, and capable institutions. Implementation is likely to proceed effectively. Mandate, funding, and lead agencies are clear and active. Policy shortfall – minor/insignificant Policies, plans, and actions, if fully delivered, would substantially address the risk. Only minimal risk remains. Risk is mitigated mainly by full implementation.	Policy coverage Aspects of the risk are covered, but some gaps in action remain. Policies and actions only partially respond to this risk. Policy mentions or touches the risk but lacks depth, detail or mandate. Readiness to implement/deliver Some delivery risks are present – e.g., unclear mandate, uneven capacity (regional variation), or coordination issues - but are partially supported. Some delivery is underway, but there are gaps in the mandate or uneven support. Policy shortfall – moderate Some risk would remain despite full implementation – for example, limits to policy scope, residual exposure. Some exposure remains (e.g., slow uptake, vulnerable populations).	Policy coverage Some important aspects of the risk are not well covered, and gaps in policy and action remain. Policy has not responded well to some important aspects of this risk. Some related policies exist, but they do not target this risk well. Readiness to implement/deliver Major delivery shortfalls. For example, institutional fragmentation, unclear responsibilities, and a lack of resources. Implementation is unlikely without significant changes, such as addressing fragmented responsibility, an unclear mandate, or missing delivery structures. Policy shortfall – major Policies, plans and actions would leave significant parts of the risk unaddressed, even if implemented as intended. Major impacts would still occur due to limitations in scope or reach.	Policy coverage The risk is not well covered, and very significant gaps in policy and action remain. Policy is either absent or has not responded to this significant risk. Risk is not mentioned or has no relevant national-level policy. Readiness to implement/deliver No realistic pathway for implementation. Lacks mandate, funding, and institutional support. Cannot be delivered under current conditions, as there is no mandate, funding, or mechanism for delivery. Policy shortfall – extreme Implementation would not reduce the risk meaningfully. Risk to people, systems or assets remains exceptionally high. Even with full implementation, core risk is not reduced.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 24: Assessment of policy readiness for all risks

Risk	Policy coverage	Readiness to implement/deliver	Policy shortfall	Overall readiness
1 Loss of access to taonga species risk	Significant gaps	Significant gaps	Extreme	Insufficient
2 Damage to Māori infrastructure	Significant gaps	Significant gaps	Extreme	Insufficient
3 Economic losses in primary industries risk	Significant gaps	Significant gaps	Major	Significant gaps
4 Disruptions to tikanga and hapū/iwi identity	Significant gaps	Significant gaps	Extreme	Insufficient
5 Loss of Indigenous knowledge systems	Significant gaps	Moderate gaps	Extreme	Insufficient
6 Legal exclusion and governance failure	Significant gaps	Significant gaps	Extreme	Insufficient
7 Increased health vulnerabilities	Significant gaps	Significant gaps	Major	Significant gaps

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.2 Loss of access to taonga species

4.2.1 Policy coverage

Across Aotearoa, the policy architecture relevant to maintaining access to taonga species can be read in three layers: direct, indirect, and enabling, with many levers seeded in Māori-led practice and shaped by tikanga. Where these levers are taken up in plans, permits, funding settings, and monitoring obligations, they help uphold the relationships between people, species, and places that sustain tikanga and kaitiakitanga. Evidence points to fragmented and uneven uptake across regions, with Te Tiriti-consistent implementation not yet systemic (Bargh & Tapsell, 2021; Mannakkara et al. 2023).

Direct policy levers are clearest where an instrument already exists or where implementation-ready methods can be required or funded. The Whaitua Te Whanganui-a-Tara Implementation Programme is a regional action framework that translates freshwater–estuary objectives into delivery pathways, including mahinga kai outcomes (Whaitua Te Whanganui-a-Tara Committee 2021). Alongside this, practical options to heal nearshore habitats, such as pathways for shifting kina-dominated reefs back toward kelp, provide methods that policy can condition into consents, restoration plans, or targeted grants (Bulmer et al. 2024). In shellfish systems, taura kuku (biodegradable spat lines) and kohunga kūtai (seed-mussel supply) offer co-designed techniques that regulators and funders can reference or require to rebuild customary stocks and associated practices (Paul-Burke et al. 2022; Skelton et al. 2023).

The evidence suggests these implementation-ready methods would benefit from dedicated, long-term resourcing and co-governed delivery mandates; there is no centrally mandated taonga-species programme indicated in the current set (Bargh & Tapsell 2021; Mannakkara et al. 2023). At the national level, the Government's climate strategy and work programme frame resilience, risk reduction, and economic transition as priorities, creating a narrative that can be used to justify scaling taonga-species restoration if explicitly tied to Māori outcomes (Ministry for the Environment 2024; Ministry for the Environment 2025e).

Indirect levers act on upstream drivers that erode taonga habitats and access. National review work links sediment, contaminants, and habitat change to declines in coastal kaimoana, strengthening the evidence base for catchment, forestry, and land-use controls as material risk reducers (Morrison et al. 2023). The Ministerial Inquiry into Land Use documents woody-debris and sediment impacts in Te Tairāwhiti/Wairoa, signalling policy directions for upstream controls that matter downstream for mahinga kai (Ministerial Inquiry into Land Use 2023). For emerging sectors, seaweed aquaculture guidance sets siting/consenting guardrails with potential co-benefits for coastal ecosystems used by iwi and hapū, giving planners and consent authorities a ready reference (Howarth & Major 2023).

Both indirect and direct levers can work at cross purposes. For example, afforestation signals linked to the ETS have been observed to displace or degrade values important to taonga species where safeguards are absent (Ministerial Inquiry into Land Use 2023). Forthcoming RMA updates, signalled through national direction reviews and RMA reform updates, could strengthen indirect levers if sediment, forestry, and coastal provisions are tightened and Te Tiriti participation rules clarified; conversely, delays or softening would perpetuate current erosion of habitats and access (Ministry for the Environment 2025b; Ministry for the Environment 2025h).

Enabling foundations support consistent, Te Tiriti-consistent implementation, but remain unevenly embedded in national policy. Climate Change Vulnerability Assessments (CCVAs) for selected freshwater taonga, and a piloted marine CCVA for tuangi (clams), offer a standard first step that

© New Zealand Institute for Bioeconomy Science Limited (2026)

central and local policies can adopt to prioritise action and investment (Egan et al. 2020). Reviews of te ao Māori marine spatial scales identify governance misfits that policy can correct to align decision scales with kaitiakitanga (Kainamu & Rolleston-Gabel 2023). Best-practice guidance for cultural indicators shows how Māori measures can be included in formal decisions (Morgan et al. 2021), while a Māori biodiversity data-sovereignty architecture sets out how environmental data can be governed for trusted uptake in statutory monitoring (Sharma et al. 2024). National stocktakes across 55 environmental attributes clarify where information is strong and where it is thin, supporting more systematic monitoring of habitats important to taonga species (Lohrer et al. 2024). There is also a policy-ready monitoring method, the Mātauranga Māori Framework for Surveillance (MMFS), which could be embedded in statutory biosecurity and ecosystem-health monitoring (Wood et al. 2024). As a complement to this, Māori-controlled geospatial platforms provide a pathway to integrate biodiversity and climate data under Indigenous governance (Sharma et al. 2024).

Capacity building through wānanga and practice-based mentoring, especially for wāhine and rangatahi, is identified as an enabling priority to sustain intergenerational implementation (Johnson, Fisher & Parsons 2022; 2024). The proposed national adaptation framework offers an organising spine for these enabling elements. However, it will only translate into coverage if its “approach” evolves into binding roles, accountabilities, and funding lines that explicitly resource Māori-led delivery (Ministry for the Environment 2025a; 2025g; 2025f).

On scale, scope, and urgency, the literature anticipates rising biodiversity pressure with climate change, indicating a need to move from pilots to catchment-to-coast programmes (Lundquist et al. 2011). The sources collectively demonstrate feasible methods, decision supports, and regional delivery vehicles. However, they do not, on their own, establish nationwide coverage or long-term resourcing at the level implied by projected pressures (Paul-Burke et al. 2022; Skelton et al. 2023; Bulmer et al. 2024). Place-based work in Te Matau-a-Maui (Hawke’s Bay) shows how applying a nature-risk lens can reveal enterprise-relevant risks and opportunities, though it remains regional in scope (Envirostrat Limited 2024). Variation in council–iwi integration further compounds the scaling gap (Mannakkara et al. 2023). The evidence overall supports encoding tikanga-based thresholds, such as harvest viability and maramataka, within plans, permits and monitoring, rather than relying solely on biophysical metrics (Morgan et al. 2021).

Regarding recognition of Māori rights, mātauranga, and Māori-led responses, the restoration exemplars are explicitly Māori-led and mātauranga-based (Paul-Burke et al. 2022; Skelton et al. 2023). Governance-scale analysis and indicator guidance provide clear routes to embed Māori perspectives within policy instruments (Morgan et al. 2021; Kainamu & Rolleston-Gabel 2023). The Te Whanganui-a-Tara programme offers a vehicle for translating local values into actions (Whaitua Te Whanganui-a-Tara Committee 2021). These sources evidence Māori-centred design and delivery; they do not, in themselves, confirm system-wide, Te Tiriti-consistent implementation. Policy commentary calls for a “tika transition”, Te Tiriti-consistent, co-governed environmental planning, to make Māori-led approaches standard rather than exceptional (Bargh & Tapsell 2021).

When we consider coverage across different time intervals/scales, it is mixed. Near-term needs are served by applied restoration and husbandry methods and by regional implementation programmes (Whaitua Te Whanganui-a-Tara Committee 2021; Paul-Burke et al. 2022; Skelton et al. 2023; Bulmer et al. 2024). Longer-term system building is supported by cultural-indicator inclusion, Māori data-sovereignty models, and national stocktakes (Morgan et al. 2021; Lohrer et al. 2024; Sharma et al. 2024). Overall, the policy toolbox is present but patchy: there are actionable techniques and enabling frameworks aligned with best-available science, yet current materials point to regional/pilot coverage rather than comprehensive, enduring investment at the scale of the risk (Lundquist et al. 2011; Morrison et al. 2023). Given the documented potential for cascading

© New Zealand Institute for Bioeconomy Science Limited (2026)

socio-ecological tipping points in Māori value networks, timely scaling is needed to prevent locking in degraded habitats, exclusionary decision rules, and maladaptive investments (Yletyinen et al. 2022; Apiti et al. 2023).

Where fast-track decisions advance high-impact projects in sensitive catchments or coastal zones without explicit mahinga kai safeguards, current coverage could be weakened. Conversely, coverage would strengthen if RMA national direction is updated to operationalise the proposed adaptation framework, translating high-level intent into enforceable duties (e.g., sediment reduction and improved water quality), Te Tiriti-consistent co-decision making and dedicated funding mechanisms for ecological restoration (Ministry for the Environment 2025b; 2025c; 2025d; 2025h).

4.2.2 Readiness to implement or deliver

Delivery is possible, but uneven. Credible Māori-led exemplars and enabling tools exist; however, roles, funding, data systems, and coordination vary across regions. Without timely system-level shifts, there is a risk of institutional lock-in that perpetuates loss of access and erodes tikanga over time (Bargh & Tapsell 2021; Kainamu & Rolleston-Gabel 2023; Mannakkara et al., 2023). The Government's climate strategy establishes a cross-portfolio direction for delivery. However, readiness for taonga restoration will hinge on whether this strategy is operationalised through binding mandates and enduring funding that seat Māori as co-decision-makers (Ministry for the Environment 2024; 2025e).

Implementation is occurring where policy vehicles and methods meet. The Whaitua Te Whanganui-a-Tara implementation programme shows how freshwater–estuary objectives can be translated into delivery pathways that include mahinga kai outcomes (Whaitua Te Whanganui-a-Tara Committee 2021). Practice-proven techniques, like reversing kina barrens toward kelp forests, using biodegradable mussel spat lines (taura kuku), and adopting iwi-led seed-mussel supply (kohunga kūtai), are already in use and can be made into conditions for consents, restoration plans, and targeted grants (Paul-Burke et al. 2022; Skelton et al. 2023; Bulmer et al. 2024). Scaling remains constrained where upstream drivers of decline, particularly sediment and contaminants, are not addressed through catchment policy and enforcement (Ministerial Inquiry into Land Use 2023; Morrison et al. 2023). In this context, subsequent RMA national-direction updates would be essential for scaling up: if these updates put clear, enforceable sediment and forestry rules in place, and resource councils to use them, the Whaitua plans can lock in mahinga kai targets, consents can require proven methods (kina-to-kelp etc.), and regional delivery becomes predictable (Ministry for the Environment 2025b; 2025h).

Clarity of roles and responsibilities is stronger in some regional settings than nationally. Whaitua arrangements illustrate coordination across ecosystems, yet mandates can blur across marine, freshwater, and biosecurity domains when Māori spatial framings and values are not embedded in statutes and plans (Whaitua Te Whanganui-a-Tara Committee 2021; Kainamu & Rolleston-Gabel 2023; Macpherson et al. 2023). The literature points to Te Tiriti-consistent co-decision as a practical route to more transparent accountability and reduced reliance on ad hoc engagement (Bargh & Tapsell 2021; Masters-Awatere, Young, Graham 2022). The proposed adaptation framework could stabilise roles across agencies if adopted as a whole-of-government platform with explicit Māori governance seats and tracked mahinga kai outcomes.

Resourcing signals are mixed. Project-level funding supports pilots and place-based work, including nature-risk framing in Hawke's Bay, but long-term, scalable investment for Māori-led monitoring and restoration is limited (Skelton et al. 2023; Envirostrat Limited 2024). Market and regulatory settings can misalign with Māori aspirations; some incentives privilege approaches that do not restore taonga or mahinga kai systems, indicating there is a need to retune signals and

align investments with tikanga-based outcomes (Pohatu et al. 2020; Ministerial Inquiry into Land Use 2023; Mika & MacDonald 2024). Technical and human capability is present but uneven. Iwi and hapū are advancing kelp recovery, mussel restoration, and tohu-based frameworks, providing a base of implementable know-how (Skelton et al. 2023; Bulmer et al. 2024; Wilcox et al. 2024). At the same time, councils and agencies often struggle to integrate mātauranga Māori and tikanga-based indicators into routine decision-making, which slows their uptake (Morgan et al. 2021; Masters-Awatere, Young, Graham 2022). Data infrastructure gaps, particularly the absence of trusted systems under Māori control, further limit operational capacity and cross-system learning (Sharma et al. 2024). Readiness could be undercut where fast-track processes become the default for major works in sensitive catchments/coasts, because compressed time frames and ministerial discretion may bypass co-governance and Māori monitoring conditions unless these are specified (Ministry for the Environment 2025c; 2025d).

To summarise, readiness will increase if: (i) RMA national direction is updated to improve ecological restoration and to embed Te Tiriti roles; (ii) the adaptation framework evolves from a proposed approach into funded mandates; (iii) fast-track criteria explicitly protect taonga habitats and Māori decision-making rights (Ministry for the Environment 2025a; 2025b; 2025c; 2025d; 2025h; 2025g).

4.2.3 Policy shortfall

Even with full implementation of the current suite of policies, plans, and practice-ready methods, a material residual risk remains for taonga species. Some policies reduce exposure and impacts in selected places, particularly where catchment controls are in place and restoration methods are resourced, but do not address the scale, persistence, and cultural dimensions of loss across rohe (Morrison et al. 2023; Skelton et al. 2023; Bulmer et al. 2024). The Government's climate strategy provides high-level direction but is not, by itself, a delivery instrument that guarantees taonga species restoration; without accompanying statutory changes and funding, residual risks persist (Ministry for the Environment 2024, 2025e). Direct levers (kina-to-kelp methods etc.) and regional programmes (e.g. Whaitua delivery) can restore habitats and practices locally, but climate-forced pressures, warming, acidification, extreme events, and legacy sediment/contaminant loads will continue to drive decline in many settings (Ministerial Inquiry into Land Use 2023; Short et al. 2023; Bulmer et al. 2024). Where upstream controls are not uniformly strengthened, residual exposure can persist even alongside successful restoration (Morrison et al. 2023). Time lags in ecosystem recovery mean benefits will arrive after some social and cultural thresholds have been crossed (Yletyinen et al. 2022; Apiti et al. 2023). Pending updates to the RMA national direction could help, but consultation alone does not change outcomes; without enforceable limits, monitoring, and clear iwi/hapū decision-making roles, cumulative effects will continue (Ministry for the Environment 2025b; 2025h).

Geographically, policy gaps are likely in estuaries and nearshore areas with high sediment loads or diffuse contaminants, and in regions where council–iwi integration is weak (Mannakkara et al. 2023; Morrison et al. 2023). Demographically, wāhine Māori, rangatahi, low-income, and urban-based whānau face ongoing barriers to safe access (transport, cost, data access), leaving tikanga-based and intergenerational outcomes under-served even when ecological metrics improve (Cram 2021; Johnson et al. 2022; Sweeney et al. 2022; Johnson, Fisher & Parsons 2024). Economically, small Māori aquaculture and customary fisheries remain vulnerable to climate shocks and market/regulatory misalignment (Envirostrat Limited 2024; Mika & MacDonald 2024). Where the fast-track pathway advances works that raise sedimentation rates, alter flow regimes, or disturb nearshore habitats, the residual risk to taonga access increases unless Te Tiriti-consistent

© New Zealand Institute for Bioeconomy Science Limited (2026)

participation and taonga-specific conditions for restoration are mandated (e.g. under process shown in Ministry for the Environment 2025d).

Catchment controls and consenting guidance can address issues relating to sediment, contaminants, and siting for new seaweed ventures (Howarth & Major 2023; Morrison et al. 2023). However, ocean warming/acidification and legacy loads (historical stocks of sediment/contaminants already stored in catchments and estuaries that remobilise over time) lie partly outside local policy reach, and incentive regimes (e.g. ETS-linked afforestation) can still counteract desired outcomes for taonga species/sites where safeguards are absent (Ministerial Inquiry into Land Use 2023). Without statutory uptake of Māori spatial framings and kaitiakitanga, governance misfits continue to dull policy effectiveness across catchments (Kainamu & Rolleston-Gabel 2023; Macpherson et al. 2023). The proposed national adaptation framework and associated independent advice identify system changes needed for climate resilience, but until their recommendations are translated into clear duties, funding baselines, and Māori data-sovereignty-compliant monitoring, residual risks will remain structurally embedded (Ministry for the Environment 2025a, 2025f, 2025g)

Even a best-effort implementation cannot entirely avoid ecological tipping risks for pāua, kūtai, kina and their related habitats under higher warming pathways. Nor can they reverse cultural losses once maramataka-based practices lapse at scale (Yletyinen et al. 2022; Short et al. 2023; Bulmer et al. 2024). Time lags mean habitats (e.g., wetlands, mahinga kai beds, shellfish reefs) recover over years to decades, even after pressures are reduced. Path dependency arises from existing land-use choices, such as forestry rotations and road construction, drainage/irrigation schemes, coastal infrastructure, long-term consents and contracts, capital investments, existing debt, and incentive settings, which keep practices in place and slow down change. Together, these factors make residual damages likely: continued access loss and degraded sites that interrupt tikanga and intergenerational mentoring (Apiti et al. 2023; Johnson, Fisher & Parsons 2024).

Evidence indicates persistent shortfalls in long-term funding, mandated co-governance, and capability to integrate mātauranga Māori in routine decisions (Bargh & Tapsell 2021; Skelton et al. 2023). There are still issues with Māori data sovereignty and monitoring. While there are guidelines for cultural indicators and the Māori Measurement Framework for Success (MMFS), they are not widely implemented. Current assessments reveal that there is not enough detailed information on important aspects related to the condition of taonga species (Morgan et al. 2021; Lohrer et al. 2024; Sharma et al. 2024; Wood et al. 2024). Where these barriers persist, adaptive learning loops are weak and residual risk accumulates.

Policy-adjacent actions that would narrow the gap include: (i) investing at scale Māori-led restoration and surveillance beyond pilots; (ii) adoption of CCVA pathways for taonga (freshwater and marine) as standard prioritisation inputs; (iii) embedding cultural indicators and MMFS in statutory monitoring, with Māori-controlled data platforms for trusted uptake; (iv) taking further infrastructure equity measures (e.g., transport access) to support safe, regular participation in mahinga kai and mentoring (Egan et al. 2020; Morgan et al. 2021; Sweeney et al. 2022; Sharma et al. 2024; Wood et al. 2024). Aligning incentives so they do not displace taonga values (e.g., afforestation safeguards) also reduces residual risk (Ministerial Inquiry into Land Use 2023). To close the shortfall, three policy approaches are required.

(1) Update and enforce RMA national direction to support ecological restoration for taonga species and to embed Te Tiriti decision-making rights.

(2) Convert the national adaptation framework from proposals to funded obligations with Māori co-governance.

(3) Amend fast-track settings to require taonga species-specific safeguards, recognition of Māori decision-making rights, and monitoring conditions as non-negotiable.

(See Ministry for the Environment, 2025a; Ministry for the Environment, 2025b; Ministry for the Environment, 2025c; Ministry for the Environment, 2025d; Ministry for the Environment, 2025g; Ministry for the Environment, 2025h).

4.2.4 Overall readiness

Table 25 summarises policy readiness for this risk. Ratings range from *Insufficient* to *Significant gaps*.

The policies for maintaining access to taonga species is present but patchy. Direct, indirect, and enabling levers exist. While many of the levers are Māori-led, uptake is fragmented, and Te Tiriti-consistent implementation is not systemic. Proven methods (kina-to-kelp transitions etc.) and regional vehicles (e.g. Whaitua implementation) demonstrate delivery pathways, but durable outcomes will depend on long-term resourcing and co-governed mandates. Indirect levers that tackle upstream drivers, that is, the root causes earlier in the chain, such as sediment, contaminants, and habitat change, are pivotal, and scaling them will require forthcoming RMA updates. Some implementation is occurring, but variable roles, funding, enforcement capacity, and data systems constrain scaling. Fast-track processes could weaken coverage unless they specify taonga species safeguards and Māori co-decision making.

Even with strong uptake, there is residual risk from climate-forced pressures, legacy loads, recovery lags, and governance misfits. Gaps in policy are most likely in high-sediment estuaries and in regions where council–iwi integration is weak, and where whānau face barriers to accessing councils. While feasible management methods, decision supports, and regional delivery vehicles exist, but the current suite does not yet establish nationwide coverage at the scale implied by pressures and risks. Readiness would strengthen if: i) the new RMA national direction embedded sediment/forestry limits and Te Tiriti roles; ii) the adaptation framework funded Māori initiatives iii) fast-track settings required taonga species-specific conditions. Implementing standing funding, CCVAs, embedded cultural indicators/MMFS, and Māori-controlled data platforms would also enhance delivery and learning outcomes.

Overall readiness: *Insufficient*. Strong practice exemplars and enabling tools are present. However, the lack of binding nationwide mandates, durable funding, and Te Tiriti-consistent governance at scale means current readiness is partial and unlikely to keep pace with rising ecological pressure; substantial residual risk remains.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 25: Policy readiness assessment for loss of access to taonga species risk

Dimension	Rationale	Score
Policy coverage	Toolbox spans direct (Whaitua delivery; kina-to-kelp; taura kuku; kohunga kūtai), indirect (catchment/forestry controls; pending RMA direction), and enabling layers (CCVAs, cultural indicators, MMFS, Māori data sovereignty). However, coverage is patchy/pilot-heavy, no centrally mandated taonga species programme, and Te Tiriti-consistent implementation is not systemic; Fast-Track Act could weaken coverage without explicit safeguards.	Significant gaps
Readiness to implement/deliver	Possible but uneven: strong Māori-led exemplars and tools, yet unclear mandates, short-cycle funding, inconsistent mātauranga Māori uptake, and data infrastructure gaps. Scaling hinges on tightened sediment/forestry rules, funded adaptation mandates with Māori co-decision-making, and preventing fast-track bypass of co-governance/monitoring.	Significant gaps
Policy shortfall	Even with best efforts, material residual risk persists due to ecological pressures, legacy loads, time-lags, governance misfits, and funding/mandate gaps; benefits are localised, while exposure and cultural loss risks remain across rohe.	Extreme
Overall readiness	Strong practice exemplars and enabling tools are present. However, the lack of binding nationwide mandates, durable funding, and Te Tiriti-consistent governance at scale means current readiness is partial and unlikely to keep pace with rising ecological pressure; substantial residual risk remains.	Insufficient

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.3 Damage to Māori infrastructure

4.3.1 Policy coverage

Damage to Māori infrastructure encompasses direct effects on marae, wharenui and wharekai, urupā, papakāinga and kura, as well as the essential lifelines and community assets that connect these places to services and decision-making. Recent events illustrate the risk: a Hawke's Bay Cyclone Gabrielle review (Bush International Consulting 2024) documents widespread failures and stresses across lifelines and response systems; kaupapa-led work on resilient wharenui has scoped practical retrofits; and Living Pā research examines tikanga-grounded design and operations for climate resilience (Hall et al. 2024). These studies provide a substantive knowledge base but are not, in themselves, policy instruments.

Within the central government's current architecture, coverage relevant to this risk is signalled through the Government's climate strategy, the climate work programme, the proposed national adaptation framework, and parallel resource management reforms. The Ministry for the Environment (MfE) outlines a cross-government strategy and work programme that frames adaptation and resilience as priorities. The proposed adaptation framework outlines a national approach, including roles and planning cycles. These materials collectively indicate the central government's intent and direction for adaptation that affects infrastructure, including kaupapa important to Māori communities. (Ministry for the Environment 2024; 2025e; 2025f; 2025g).

Two legislative and policy reform tracks are particularly material for Māori infrastructure. First, the Fast-track Approvals Act 2024 (see https://www.legislation.govt.nz/act/public/2024/0056/latest/LMS943260.html) established an accelerated consenting pathway for specified projects. From a coverage perspective, it can enable risk-reducing works (for example, flood protection or safety upgrades adjacent to marae) to proceed more quickly. However, acceleration may also compress engagement time frames unless processes are explicitly resourced and centre on iwi and hapū decision-making (Ministry for the Environment 2025c).

Second, MfE's June 2025 Resource Management (RM) reform update and the consultation on updating national direction indicate potential shifts to planning rules and standards that shape where and how infrastructure is located, upgraded, or withdrawn. If strengthened, national direction could embed hazard-risk information and mātauranga Māori into local plans, clarifying expectations for councils and network utilities across rohe. (Ministry for the Environment 2025b; 2025h). At the interface of community evidence and policy design, Te Puni Kokiri's publication on understanding climate hazards for Māori (Te Puni Kōkiri 2023) collates hazard exposure insights that are directly relevant to Māori infrastructure and settlement patterns. This resource contributes to coverage by enhancing the information base for risk screening and prioritisation, while acknowledging that it is a guidance product rather than a statutory requirement.

Direct levers currently visible in the public material include the fast-track consenting pathway for named projects and the prospect of updated resource management national direction that could set clearer standards for risk-sensitive infrastructure decisions. Indirect levers include the climate strategy and overall work programme, which coordinate sectoral efforts and may influence the delivery of transport, housing, heritage, and water services, particularly as these portfolios align with adaptation objectives. Enabling levers include the proposed adaptation framework, which would structure assessment, planning and funding conversations across time and levels of government. These levers collectively create avenues through which marae, urupā and papakāinga-related infrastructure can be considered in land-use and investment choices. (Ministry for the Environment 2024; 2025a; 2025b; 2025c; 2025g; 2025h).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Research fills several important gaps by specifying what “Māori infrastructure” means in practice and by testing solutions. Work on resilient wharenui, kaupapa Māori-led co-design, and tikanga-based operations demonstrates feasible methods for climate adaptation approaches (Hall et al. 2024). Emergency management reviews identify where response and recovery systems can fail Māori communities (Bush International Consulting 2024). Finally, empirical analyses of hazard events, such as the attribution work on Cyclone Gabrielle rainfall, make the case for proactive risk treatment (Harrington et al. 2023). All these research references serve as evidence of need and feasible practice, rather than policy commitments.

In relation to Te Tiriti obligations, the public-facing MfE material outlines national direction, processes and roles. However, it does not, on its own, create binding co-decision-making powers for iwi and hapū in infrastructure adaptation. Research on tikanga-grounded governance and ethical practice suggests pathways to embed rangatiratanga in planning and delivery; these are conceptually strong foundations that will require translation into mandates, standards, and sustained funding to achieve coverage. (Bargh & Tapsell 2021; Tapsell 2022; Ministry for the Environment, 2025g).

Overall, coverage for damage to Māori infrastructure is emerging and uneven. There is visible government intent and a developing framework; there are acceleration tools that can help or hinder depending on how Māori decision-making is provided for; and there is a strong research base demonstrating practicable solutions and the consequences of inaction. The distinction between policy and research is material to this assessment: much of the detail on Māori infrastructure needs and solutions is found in research and reviews, while the binding policy settings that would make those solutions standard practice are still being developed or consulted on (Bush International Consulting 2024; Deep South Challenge 2024; Hall et al. 2024; Ministry for the Environment 2024; 2025a; 2025b; 2025c; 2025g; 2025h).

4.3.2 Readiness to implement or deliver

Readiness depends on whether the signals and levers above can be delivered for marae, papakāinga, and related assets effectively and practically. The Government’s proposed national adaptation framework outlines a structured approach and acknowledges the need for coherent roles; however, the public documents suggest an evolving system. Until the framework is finalised and embedded in guidance, funding channels and performance expectations, delivery will depend on local capability, existing statutory tools and the speed of resource management reforms. (Ministry for the Environment 2025a; 2025g; 2025h).

The fast-track pathway can accelerate delivery speed for protective works or rebuilds where projects meet the criteria, yet readiness for Māori infrastructure depends on whether iwi and hapū are adequately resourced to engage at pace and whether project selection reflects Māori priorities for place-based resilience. The description of the fast-track process emphasises acceleration; but readiness for equitable outcomes requires clarity on participation, evidence standards and protections for wāhi tapu, wāhi tūpuna and urupā within condensed time frames. (Ministry for the Environment 2025c; 2025d).

There is real-life delivery experience to draw from, but it is patchy and often pilot-based. The Adaptation by Mana Whenua programme (see Stephenson, Kawharu et al. 2023; Stephenson, Rewi et al. 2023) documents initiatives, barriers and partnering models with councils; these demonstrate workable practices, including co-design and tikanga-led processes, but they are not universal or mandated). Similarly, the Living Pā and marae-resilience programmes provide technical and organisational templates that could be scaled if funding and standards point in that

direction (Deep South Challenge 2024; Hall et al. 2024). These two projects are valuable proofs of concept rather than indicators of system-wide readiness.

Emergency management findings from Cyclone Gabrielle highlight coordination, resourcing, and information-sharing challenges that directly affect Māori infrastructure repair and protection. These readiness constraints include the ability to mobilise building assessments, provide temporary accommodation for whānau linked to marae, and timely debris and sediment management. The insights are actionable but require resourced local and iwi capacity to convert into improvements. (Bush International Consulting 2024). Readiness is also a function of data, standards and decision-support that respect mātauranga Māori and Māori data sovereignty. Work on cloud-based data systems reveals pathways to protect sensitive cultural and biodiversity data while enabling inter-agency use. If adopted into government platforms and procurement, such approaches can accelerate culturally safe assessments and monitoring for Māori sites and assets. Currently, these approaches are research and technology proposals rather than mandated infrastructure in the policy framework. (Sharma et al., 2024).

Hazard intelligence and exposure screening for Māori settlements and facilities are improving. Te Puni Kōkiri's hazard resource (Te Puni Kōkiri 2023) supports readiness by consolidating knowledge about risks to hapū Māori that can guide local planning and investment decisions. Its use depends on alignment with the national adaptation framework, updates to the national direction of resource management, and a council's capability to embed the insights into consenting, asset management, and community-led planning. (Ministry for the Environment 2025a, 2025b).

Overall readiness is advancing, but it remains contingent on the following. There are promising delivery exemplars and clearer national signals emerging. However, critical enablers, durable funding streams matched to Māori infrastructure, explicit Te Tiriti-based roles in local and regional decision making, technical standards that integrate mātauranga Māori, and capacity within iwi, hapū and councils, remain in development or vary by region. The policy materials we've reviewed suggest solutions but do not, at this stage, guarantee uniform delivery of Māori infrastructure at the scale needed by recent extreme weather events. (Bargh & Tapsell 2021; Ministry for the Environment 2025a; 2025g).

4.3.3 Policy shortfall

Even with the full implementation of the current signals, residual risk to Māori infrastructure is likely to persist due to exposure, legacy siting, cultural significance, and uneven capacities. Historical relocation of Māori communities in response to hazards reveals that physical moves can occur without addressing the more profound cultural, social, and economic effects. As climate hazards intensify, this history cautions against if relocation or rebuilding will fully mitigate loss (Bailey-Winiata et al. 2024). Upstream drivers of damage, such as the mobilisation of sediment and woody debris, can overwhelm assets and recovery systems, with disproportionate effects on remote Māori communities and the assets that serve them, including roads, bridges, and marae. The Ministerial Inquiry into Land Use (2023) outlined the scale and mechanisms of slash and sediment harms in Tairāwhiti/Wairoa (i.e. East Coast/Wairoa). It concluded that even with stronger planning rules, the time lags and enforcement challenges mean that residual risk may persist for years in high sediment-loading catchments.

Socio-economic stressors interact with infrastructure damage to produce compounded losses. Research on the experiences of wāhine Māori during climate events reveals how service disruptions, unsafe housing, and displacement can exacerbate harm. Such findings highlight that infrastructure programmes must account for intersecting needs, or the benefits will be uneven. This

© New Zealand Institute for Bioeconomy Science Limited (2026)

is critical for marae-centred networks that coordinate care, shelter and decision making. These studies enrich our understanding of risk, but do not, by themselves, ensure adequate policy coverage. (Johnson, Fisher & Parsons 2022; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Cultural loss risks are not fully reducible to engineering solutions. Damage or relocation affecting urupā and whare tīpuna can sever ties to place and disrupt tikanga, with long-lasting consequences. Community-led scholarship on mahi aroha during disasters and on tikanga-centred governance demonstrates how whānau mobilise to reduce harm. However, without binding mechanisms and sustained resourcing in the policy stack, the burden of adaptation can continue to fall on volunteers and under-resourced organisations (Cram 2021; Tapsell 2022).

Policy can also fall short if national tools do not yet guarantee Te Tiriti-based co-decision-making for infrastructure adaptation. The proposed national adaptation framework and resource management updates describe an approach and potential content but stop short, in their public form, of mandating shared authority for iwi and hapū over siting, protection, or managed retreat affecting Māori infrastructure. In accelerated consenting, compressed time frames may further limit the meaningful incorporation of mātauranga Māori unless specific provisions and resourcing are established. These observations highlight the distinction between strategic and enforceable settings (Ministry for the Environment 2025a; 2025b; 2025c; 2025g). Information and tooling gaps contribute to residual risk. Te Puni Kōkiri's hazard resource (Te Puni Kōkiri 2023) improves situational awareness for hapori Māori; and climate-attribution science reinforces the rationale for forward-leaning decisions. However, embedding these insights into statutory instruments, asset registers, and funding prioritisation is still a work in progress (Harrington et al. 2023; Sharma et al. 2024). Until hazard intelligence, tikanga-centred standards and Māori data governance are normalised in council and Crown practices, uneven protection will remain.

Even if current plans, frameworks, and fast-track processes are fully implemented, disproportionate residual risks for Māori infrastructure are foreseeable where exposure is high, legacy siting is challenging to change, and governance, funding, and standards do not yet guarantee Māori decision making or the routine integration of mātauranga Māori. Addressing the shortfall entails strengthening the national direction of resource management, specifying Te Tiriti-based roles in adaptation and infrastructure programmes, resourcing iwi and hapū as delivery partners, and scaling tested kaupapa Māori-led models for marae and papakāinga adaptation. All these policies need to move beyond guidance and pilots into mandates, durable funding, and clear accountability. These policies are consistent with the direction of current government approaches but require further codification to meet the scale of risk. (Bargh & Tapsell 2021; Stephenson Kawharu et al. 2023; Stephenson, Rewi et al. 2023; Ministry for the Environment 2025a; 2025b; 2025g).

4.3.4 Overall readiness

Table 26 summarises policy readiness for this risk. Ratings range from *Insufficient* to *Significant gaps*.

Aotearoa's current approach provides signals rather than settled, enforceable protections for Māori infrastructure. Policy coverage is visible through the Government's climate strategy and work programme, the proposed national adaptation framework, fast-track consenting, and resource management reform. These can support risk-reducing works and clearer planning expectations, and Te Puni Kōkiri's hazard resource (Te Puni Kōkiri 2023) improves the evidence base for prioritising marae, papakāinga, and related assets. However, most elements are either proposed, enabling, or discretionary. Te Tiriti-based co-decision-making over siting, protection, and managed retreat is not yet mandated, leaving iwi and hapū authority contingent on local practice.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Readiness to implement mirrors this pattern. Pilot-tested models (e.g., marae-resilience programmes, mana whenua–council partnerships, tikanga-grounded facility design/operations) show how delivery could work. However, scaling requires durable funding, clear mandates, technical standards that integrate mātauranga Māori, and resourced participation, particularly where consenting is accelerated. Variability in council capability and the absence of normalised Māori data governance, however, have led to slow and inconsistent uptake. The shortfall remains high even with the full implementation of current signals. Structural drivers, legacy siting, upstream sediment and woody debris, and the cultural irreversibility of harm to urupā and whare tīpuna mean that engineering fixes alone are insufficient. Without binding Te Tiriti arrangements, tikanga-centred standards, and asset registers that guide routine investment and maintenance, residual risk will continue to fall disproportionately on Māori communities.

Overall readiness: *Insufficient.* The system shows intent and some direct levers (accelerated works; potential national direction). However, enabling frameworks are unsettled, mandates/funding are unclear, and capability varies widely. Reviewed research demonstrates feasibility, but policy instruments to scale and sustain delivery are incomplete. Given persistent shortfalls and uncertain delivery, the system is not ready to reliably reduce damage to Māori infrastructure at the required scale.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 26: Policy readiness assessment for damage to Māori infrastructure

Dimension	Rationale	Score
Policy coverage	Coverage is emerging across the Government's climate strategy/work programme, the proposed national adaptation framework, fast-track consenting for named projects, and resource management reform, with possible updates to national direction. Te Puni Kōkiri's hazard resource (Te Puni Kōkiri 2023) provides evidence but serves as guidance. Evidence from the research identifies methods, but it is not a binding policy. Te Tiriti-based co-decision making is not yet mandated; coverage therefore remains uneven across rohe and instruments.	Significant gaps
Readiness to implement/deliver	Delivery depends on finalising/embedding the adaptation framework, aligning the national direction of resource management, and resourcing iwi/hapū participation, especially under accelerated consenting. Current practice is patchy and often pilot-led (mana whenua partnerships, marae-resilience), with variable council capability and unclear, durable funding. Māori data governance/standards are still proposals. There are workable exemplars, but a reliable, scalable delivery pathway is not yet in place.	Significant gaps
Policy shortfall	Even with full implementation of current signals, substantial residual risk remains from upstream drivers (sediment, woody debris), legacy siting, and the irreversibility of damage to marae, wharenui and urupā. Fast-track compression may limit the integration of mātauranga Māori. Absent binding Te Tiriti-based co-decision making and normalised, resourced tikanga-centred standards and asset registers, protection will remain uneven and losses disproportionate.	Extreme
Overall readiness	The system shows intent and some direct levers (accelerated works; potential national direction). However, enabling frameworks are unsettled, mandates/funding are unclear, and capability varies widely. Reviewed research demonstrates feasibility, but policy instruments to scale and sustain delivery are incomplete. Given persistent shortfalls and uncertain delivery, the system is not ready to reliably reduce damage to Māori infrastructure at the required scale.	Insufficient

Table note: Shading indicates severity. Green = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. Yellow = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. Orange = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. Red = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.4 Economic losses in primary industries

4.4.1 Policy coverage

Across Māori participation in farming, forestry, fisheries and aquaculture, policy coverage for climate-related economic losses has strengthened. However, alignment with Māori ownership structures, decision rights and intergenerational objectives is still uneven. There is clear high-level direction for a just transition grounded in tikanga and Te Tiriti o Waitangi, yet many delivery instruments continue to operate through generic eligibility rules, mainstream advisory pipelines and capital settings that do not fully account for whenua Māori tenure, collective governance, or tikanga-anchored risk preferences (Bargh & Tapsell 2021; Kingi 2008; Tapsell 2022). Post-event reviews and land-use inquiries have sharpened focus on exposure and landscape fragility, particularly sediment, slash and roading dependencies in steep catchments, providing important signals for risk reduction, but these assessments do not, by themselves, resolve recurrent loss profiles or the financing of long-run transitions (Buckley et al. 2023; McMillan et al. 2023; Ministerial Inquiry into Land Use 2023). The Government's climate strategy and climate work programme set an overarching direction across mitigation and adaptation that can be read as enabling coverage for primary-industry risk reduction, particularly where agencies align investment, regulation and procurement with resilience outcomes (Ministry for the Environment 2024; 2025e).

Within food and fibre, research-informed guidance and pilot initiatives point to diversified value chains, nature-based solutions, and mātauranga-science co-design as ways to stabilise productivity and reduce downside risk. Long-term agroecosystem and catchment trials indicate potential to lift resilience and revenue stability, yet integration into durable policy, through incentives, procurement standards and planning rules, remains emergent (Buckley et al. 2023). Māori-led land-use design frameworks demonstrate how co-governed planning that centres rangatiratanga can align productivity with tikanga, ecosystem repair and risk mitigation, offering a more straightforward policy pathway than one-off projects (Percy et al. 2024). On the demand side, place-based provenance, tikanga-anchored standards and reciprocity-based trade models are developing, but mainly as research, pilots and guidance; stronger policy linkages via certification recognition, public procurement and export settings would help Māori producers capture value without prohibitive compliance costs (Reid et al. 2023; Rout & Whitehead 2023). The proposed national adaptation framework provides a structure for clarifying roles, priorities and sequencing of adaptation actions, which, if adopted, can embed these pilots and co-design models into durable, cross-agency policy (Ministry for the Environment 2025a; 2025g).

Blue-economy policy coverage has widened, with more explicit routes for aquaculture growth and marine ecotourism. Nonetheless, Māori-specific loss reduction is still mediated primarily by consenting pathways, cumulative-effects management and sector guidelines rather than by dedicated risk instruments (Howarth & Major 2023; Rout et al. 2023). Evidence that mātauranga-science partnerships can overcome critical bottlenecks, such as seed mussel supply, shows where targeted policy approaches could mitigate the risk of not meeting the supply of mussel spat for markets (Skelton et al. 2023). Environmental guidance for seaweed aquaculture is increasingly translatable into predictable consent conditions, which could reduce stranded-investment risk if embedded in policy and planning instruments (Howarth & Major 2023). The Fast-track Approvals Act 2024 creates a parallel approvals pathway for eligible projects, potentially reducing time and uncertainty for resilient infrastructure and primary-industry investments; however, coverage for Māori loss-reduction depends on how selection/referral criteria and process safeguards uphold Te Tiriti commitments and cumulative-effects management (Ministry for the Environment 2025c; 2025d).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Disclosure-oriented policy is an emerging approach within the finance sector with the potential to move investment toward climate-resilient approaches. Nature-related risk and opportunity frameworks will shape expectations for Māori agribusinesses and fisheries; if tools are co-designed and proportionate, disclosure can catalyse investment into low-risk, tikanga-aligned practices, but Māori-specific enablement (data sovereignty, capability, and scaled templates) still needs more explicit articulation (Mitchell & Seymour 2023; Envirostrat Limited 2024). Data policy intersects directly with operational risk in surveillance and biosecurity: frameworks that embed mātauranga and uphold Māori data sovereignty can reduce the probability and duration of losses from pests and pathogens while maintaining trust (Lambert & Mark-Shadbolt 2021; Sharma et al. 2024; Wood et al. 2024). Finally, iwi corporate strategies indicate a maturing internal policy environment that integrates climate risk, diversification and intergenerational asset protection. However, public policy conditions, consenting timetables, infrastructure dependencies and disaster cost-sharing continue to shape the feasible envelope for Māori enterprises (Te Rūnanga o Ngāi Tahu Group 2024). Ongoing RMA reform work and consultation on updating national direction signal potential standardisation of hazard, freshwater and biodiversity settings, which could improve cumulative-effects management across catchments relevant to Māori producers (Ministry for the Environment 2025b; 2025h).

4.4.2 Readiness to implement or deliver

Readiness is strongest where Māori organisations already lead end-to-end delivery and possess durable governance, balance sheets and trusted partnerships. Large iwi entities increasingly integrate climate risk into portfolio management, reallocating capital toward resilient land uses and co-investing in enabling infrastructure; this creates immediate absorption capacity for concessional finance, tailored procurement and streamlined consenting (Te Rūnanga o Ngāi Tahu Groups 2024). At the farm and incorporation scale, kaupapa-driven land-use change has been demonstrated where finance, technical advice and local planning settings align, signalling operational readiness to scale when policy instruments are predictable and multi-year (Buckley et al. 2023; Tai-o-Rongo Research Collective 2024). The Fast-track approvals process sets out defined steps, roles and statutory timeframes, indicating procedural readiness for projects that meet eligibility and referral tests; practical readiness for Māori outcomes will depend on how decision-makers weigh Te Tiriti-consistent evidence and cumulative effects within that process (Ministry for the Environment 2025d).

Delivery systems for surveillance and biosecurity show practical pathways for embedding mātauranga alongside science, with pilots demonstrating improved detection, community legitimacy and faster response cycles. The challenges focus more on having stable funding, developing the workforce, and creating data systems that respect Māori data sovereignty while enabling Māori to utilise that data for decision-making (Lambert & Mark-Shadbolt 2021; Sharma et al. 2024; Wood et al. 2024). On the finance-disclosure interface, early needs assessments suggest Māori producers and fisheries businesses can use sustainability-linked instruments and nature-related reporting, provided co-designed tools keep reporting burdens proportionate, and direct benefits, lower capital costs, and market access are tangible (Mitchell & Seymour 2023; Envirostrat Limited 2024).

The proposed national adaptation framework sets out an intent to establish an enduring, long-term approach to adaptation, clarify roles and responsibilities and cost-sharing, and improve information-sharing across the system. For Māori primary sectors, turning that intent into reduced economic loss is likely to require co-designed governance with Te Tiriti partners, predictable multi-year funding that fits collective title, Māori data-sovereignty and mātauranga-based indicators in risk/disclosure tools. It will also require nationally consistent (fit-for-purpose) consent/monitoring

templates to reduce regional variability, with related policy outlined in the RMA national-direction updates and the implementation of the Fast-track Act, rather than just as principles on the national adaptation framework webpage (Ministry for the Environment 2025a; 2025f; 2025g).

In aquaculture and coastal ventures, technical readiness is mixed but tractable. Solutions for seed mussel supply emerging from mātauranga-science partnerships reduce a key constraint for shellfish expansion, while environmental guidance for seaweed aquaculture clarifies thresholds that, if embedded in policy, can shorten consent timeframes and reduce regulatory uncertainty (Howarth & Major 2023; Skelton et al. 2023; Rout et al. 2023). However, readiness weakens at multi-agency interfaces where cumulative effects, coastal hazards and legacy land uses coincide; even motivated proponents face delays when roles and standards are unclear across statutes and jurisdictions (McMillan et al. 2023; Ministerial Inquiry into Land Use,2023). The climate work programme provides a portfolio view across agencies that can enable alignment of consenting, infrastructure and procurement levers; readiness improves where these instruments are applied in concert and with multi-year horizons (Ministry for the Environment 2025e).

It is important to distinguish policy from research in interpreting readiness. Many of the strongest readiness signals come from research programmes, pilots and feasibility studies that demonstrate viable models and co-design processes; the policy levers that convert demonstrations into sector-wide practice, long-run funding, enabling regulation, standardised consent templates, and preferential procurement are still consolidating (Buckley et al. 2023; Percy et al. 2024). In practice, Māori communities and enterprises are frequently ready to act; the system’s readiness hinges on whether policy consistently resources, mandates and simplifies the pathways they must navigate. Until RMA national direction updates are finalised and implemented, variability in consent practice and standards will continue to create uneven timelines and costs for Māori businesses, dampening near-term readiness to scale proven models (Ministry for the Environment 2025; 2025h).

4.4.3 Policy risks

Even with full implementation of signalled actions, residual economic risk will remain material for Māori in primary industries because exposure, market structure and ecological dynamics are only partially controllable through policy. Regime shifts such as kina barrens suppress kaimoana productivity and take sustained effort to reverse, leaving iwi and hapū exposed to prolonged revenue loss unless restoration programmes are long-term and adequately funded (Bulmer et al. 2024). Plant and pathogen incursions can generate sudden, asymmetric losses. However, surveillance frameworks exist, under-resourcing, fragmented data governance and slow operational uptake of mātauranga can raise the probability of undetected spread and lengthen downtime (Lambert & Mark-Shadbolt 2021; Wood et al. 2024). Some residual risk will remain even with full policy implementation due to exposure, legacy land uses and system limits (e.g., hazards in steep catchments); new instruments must avoid lock-in and address cumulative effects to reduce losses materially.

Structural constraints on whenua Māori, including fragmented titles, limited collateral and transaction costs, continue to cap the speed of adaptation and the ability to capture value-added premiums even when opportunities are identified, meaning some loss potential persists despite good planning (Kingi 2008). Market strategies that focus on reciprocity and proving authenticity can lose value if the standards aren't widely recognised or if smaller Māori producers bear most of the verification costs. policy can mitigate this, but uneven adoption across buyers and jurisdictions will leave residual exposure with producers (Reid et al. 2023; Rout & Whitehead 2023). In the blue economy, there is a risk that growth reproduces extractive logics unless governance protects rangatiratanga and ensures gains are retained locally; without such safeguards, volatility,

© New Zealand Institute for Bioeconomy Science Limited (2026)

reputational harm and cultural loss can compound economic risks (Bargh & Tapsell 2021; Rout et al. 2023). The Fast-track pathway, while expediting decisions, could leave Māori exposed to residual loss if safeguards for Te Tiriti, cumulative-effects assessment, and hapū/iwi decision-making rights are not consistently embedded in project referrals and approvals (Ministry for the Environment 2025c; 2025d).

Data and disclosure obligations may also create residual risk if compliance architectures are not designed with Māori enterprises in mind. Failure to embed data sovereignty increases legal, cultural and relational risks and may deter participation in otherwise beneficial schemes (Sharma et al. 2024). In terms of hazards, recurrent storms and landslides will continue to damage productive assets and transport lifelines even under improved practice. At the same time, inquiries and assessments reduce uncertainty; they cannot eliminate exposure in erosion-prone catchments, necessitating insurable solutions and credible public risk-sharing to avoid repeated capital impairment (McMillan et al. 2023; Ministerial Inquiry into Land Use 2023). Until the national adaptation framework is fully adopted and operationalised, gaps in coordination, resourcing and long-term funding signals are likely to persist, leaving Māori producers with uneven access to enabling supports during the transition (Ministry for the Environment 2025a; 2025g; 2025f).

Finally, policy shifts can generate indirect, cascading cultural and economic effects, especially where access to key environmental elements is constrained, reinforcing residual losses that are slow to reverse; this underscores the need for policy stewardship that anticipates cross-domain consequences and centres Māori values in design and implementation (Yletyinen et al. 2022). Compounding dynamics across housing, health, infrastructure and regulation can magnify climate-driven shocks or delay recovery, which argues for integrated settings that align institutions, time horizons and investment cycles rather than relying on one-off fixes (Awatere et al. 2021; Lück et al. 2024).

Once the national direction aligns with the climate work programme, the path should become more predictable and financeable**.** However, suppose national direction does not embed Te Tiriti provisions. In that case, Māori in the primary sector may face higher transaction costs and litigation risk, uneven consent conditions across regions, harder access to capital and insurance, and a greater chance of stranded or retrofit-exposed investments, especially where Fast-track processes move quicker than protections, and RMA settings under-specify cumulative effects in vulnerable catchments and coasts (Ministry for the Environment 2024; 2025b; 2025e; 2025h).

4.4.4 Overall readiness

Table 27 summarises policy readiness for this risk. Ratings are all for *Significant gaps*.

Policy coverage is broadening across mitigation and adaptation signals (climate work programme, proposed national adaptation framework, disclosure tools) and sector guidance (blue-economy, mātauranga–science pilots), but it remains broadly enabling. Māori-specific loss reduction still relies on generic consenting pathways, emerging standards, and pilots. Readiness is strongest where Māori organisations already lead end-to-end delivery (iwi portfolio shifts, proven land-use change, aquaculture/biosecurity co-design), yet it weakens at multi-agency interfaces and with regional variability in consent practice; mandates and multi-year funding are not yet settled. Policy shortfalls are material, including ecological regime shifts, pests/pathogens, steep-catchment hazards, structural finance constraints on whenua Māori, and potential misalignment of Fast-track/RMA settings with Te Tiriti and cumulative-effects management, which means residual losses remain high even with full implementation.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Overall readiness: *Significant gaps.* The system has meaningful, growing coverage and demonstrated delivery pockets. However, major residual risk remains without settled national direction, durable multi-year funding, proportionate disclosure/data-sovereignty tools, and consistently Te Tiriti-aligned processes (including Fast-track). On balance, moderate coverage, and moderate delivery readiness result in a significant residual shortfall, ultimately landing overall readiness at significant gaps.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 27: Policy readiness assessment for economic losses in primary industries risk

Dimension	Rationale	Score
Policy coverage	Coverage spans mitigation/adaptation signals (Government climate strategy and work programme), proposed Adaptation Framework, disclosure/nature-related risk tools, blue-economy guidance, and ongoing RMA national-direction updates. However, much of this is enabling or emerging; Māori-specific loss-reduction relies on generic consenting pathways, pilots, and guidance. Fast-track benefits depend on how Te Tiriti commitments and cumulative effects are upheld in referrals/approvals.	Significant gaps
Readiness to implement/deliver	Readiness is strongest where Māori organisations already lead end-to-end delivery (iwi corporates reallocating capital; demonstrated land-use change when finance/advice/planning align). Practical pathways exist in biosecurity/surveillance and aquaculture (e.g., seed mussel supply solutions). However, readiness weakens at multi-agency interfaces, with regional variability in consent practice and standards, and key levers (national direction, Adaptation Framework) still consolidating.	Significant gaps
Policy shortfall	Even under full implementation, residual economic risk for Māori remains material due to ecological regime shifts (e.g., kina barrens), pest/pathogen incursions, steep-catchment hazards, structural constraints on whenua Māori finance/governance, market structure/verification costs, and potential Fast-track/RMA misalignment with Te Tiriti and cumulative-effects management. Until long-run funding, nationally consistent templates, and co-governed settings are locked in, significant residual loss persists.	Major
Overall readiness	The system has meaningful, growing coverage and demonstrated delivery pockets. However, major residual risk remains without settled national direction, durable multi-year funding, proportionate disclosure/data-sovereignty tools, and consistently Te Tiriti-aligned processes (including Fast-track). On balance, moderate coverage, and moderate delivery readiness result in a significant residual shortfall, ultimately landing overall readiness at significant gaps.	Significant gaps

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.5 Disruptions to tikanga and hapū/iwi identity

4.5.1 Policy coverage

Across Aotearoa, policy relevant to safeguarding tikanga and hapū/iwi identity exists in three layers: direct, indirect, and enabling, but the current balance of policy skews toward principles or statements rather than funding, mandates or enforcement. National frameworks acknowledge Māori interests yet stop short of mandating Te Tiriti-based governance or tikanga-based planning (Masters-Awatere, Young, & Graham 2022; Tapsell 2022). A proposed Climate Adaptation Act (signalled by the Government as the key mechanism for managed retreat) and in which Māori were named as stakeholders remains undeveloped. As of 2025, no bill has been introduced, and policy settings for the bill are still under internal review (Expert Working Group on Managed Retreat 2023; Rout et al. 2025).

The Fast-track Approvals Act 2024 establishes a permanent, “one-stop-shop” alternative to standard RMA pathways, with a large pipeline of pre-listed projects. At the same time, this expands policy coverage for rapid delivery of housing and infrastructure, but it does not, on its face, guarantee Te Tiriti-based governance or tikanga-based planning for decisions that may affect wāhi tapu, marae, and kāinga. This risks creating a coverage–shortfall gap for protecting Māori rights and interests (Ministry for the Environment 2025a; 2025b). The RMA reforms under way focus on updating national direction (including freshwater management), with consultation open on whether changes proceed under the current RMA or a new regime. This consultation offers potential coverage gains if co-decision making and Māori authority are embedded, but that remains uncertain at this stage (Ministry for the Environment 2025c; 2025d). If the Government’s proposed national adaptation framework codifies tikanga-based retreat protocols, it could shift coverage from recognition to operational protection. However, at present, that framework is still in development (Ministry for the Environment, 2025e; 2025f). At the strategic level, the Government’s climate programme and strategy signal an intent to build a “fair and enduring adaptation system.” However, these high-level signals only translate into coverage where they are backed by instruments that seat hapū/iwi authority in decisions (Ministry for the Environment 2024; 2025g).

Recent evidence of practice also shows councils partnering with iwi/hapū on co-planning, but often without apparent authority to realise tikanga-based objectives at scale (Masters-Awatere, Young, & Graham 2022; Stephenson, Kawharu et al. 2023). By contrast, Māori-led efforts provide direct policy-relevant exemplars: Project Kāinga is a five-year research programme working with marae communities to plan and test tikanga-based responses to climate change) and other work re-embed whakapapa and ahi kā in housing, infrastructure and settlement design, demonstrating how adaptation can sustain mana motuhake (autonomy) when governance and investment align (Berghan 2021; Andersen 2024; Resilience to Nature’s Challenges 2024a, 2024b). Related kāinga and place-based evidence also points to practical pathways for identity-anchored regeneration (Munro 2021; Tai-o-Rongo Research Collective 2024). However, these efforts remain peripheral to state-led adaptation and under-resourced relative to need (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Tai-o-Rongo Research Collective 2024).

Indirect levers exist but are inconsistently activated. National inquiry findings on land-use, erosion and debris, together with coastal hazard management and heritage protection tools, could materially reduce pressures on marae, kāinga and urupā if applied through Te Tiriti-consistent co-decision making (Ministerial Inquiry into Land Use 2023; Pohatu & Walker 2021). Factors that might enable such activation are known but are not really embedded in process development. For example, the MfE

© New Zealand Institute for Bioeconomy Science Limited (2026)

has commissioned tikanga-based guidance for managed retreat; initiatives such as a Māori Climate Platform, and a dedicated Māori resilience fund outline vehicles for Māori governance over adaptation resources. In addition Māori data sovereignty architectures and mātauranga-aligned monitoring show how measures of mana, whakapapa continuity and ahi kā can be included in formal decisions (Hall et al. 2024; Sharma et al. 2024).

On scale, scope and urgency, current policies do not match the exposure trajectory: displacement risks, loss of wāhi tapu and identity disruption are already present in low-lying and erosion-prone places, while near-term managed retreat proposals often proceed without a tikanga-based framework (Tapsell 2022; Expert Working Group on Managed Retreat 2023; Stephenson, Kawharu et al. 2023). Alignment with best-available science is partial: policy often references hazard projections without pairing them to tikanga-grounded thresholds or high-emissions contingencies for cultural heritage (Yletyinen et al. 2022; Erueti et al. 2023). Overall, coverage is present but patchy, strongest in Māori-led exemplars and early guidance, but lacks the system mandates required for nationwide, Te Tiriti-consistent protection of tikanga and identity (Berghan 2021; Andersen 2024; Rout et al. 2025).

4.5.2 Readiness to implement or deliver

Delivery is possible where Māori-led vehicles exist, but uneven and fragile within state systems. Whānau, hapū, and iwi have demonstrated implementable models (e.g., for kāinga regeneration, marae-led planning, and maramataka-informed natural resource management) that translate identity protection into housing, infrastructure and land-use choices (Berghan 2021; Andersen 2024; Tai-o-Rongo Research Collective 2024). On-the-ground readiness is further evidenced in Māori disaster response and welfare coordination, where hapū/iwi organisations mobilise quickly and maintain continuity for high-risk groups (Cram 2021; Stephenson, Kawharu et al. 2023). The Fast-track Act is already operational, with applications open, expert panels in place, and cost-recovery regulations. This indicates a high “system” readiness to approve projects quickly, but it may compress participation windows and shift effort onto hapū/iwi to respond at speed, challenging tikanga-grounded process readiness (Ministry for the Environment 2025a; 2025h).

Unfortunately, roles and responsibilities remain blurred nationally: managed retreat, heritage protection, housing, insurance and emergency recovery sit across agencies whose mandates do not consistently embed Te Tiriti–obligations or collective tenure, producing procedural inclusion but substantive exclusion (Whitehead & Walker 2021; Erueti et al. 2023; Rout et al. 2025). In contrast, the resource-management reform is currently mid-consultation, so practical readiness depends on transitional use of the existing RMA, leaving significant geographic variability in how councils recognise tikanga and mana whakahaere (Ministry for the Environment 2025c; 2025d). Funding and institutional support are intermittent. Māori initiatives frequently face short-term, compliance-heavy criteria misaligned with te ao Māori outcomes, while marae, kāinga and urupā are often undervalued in recovery and investment logics (Whitehead & Walker, 2021).

The Government’s national adaptation framework is still being developed, and until decisions are made and its policy is published, it will not improve policy readiness (Ministry for the Environment 2025e, 2025f). Technical and human capability is strong in communities, particularly through wāhine-led care and governance networks, but capacity is eroded by under-investment and fragmented engagements (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). The Government’s overarching climate strategy and work programme framing provide directional readiness (e.g., forthcoming Cabinet decisions and system design), but do not themselves resolve the

© New Zealand Institute for Bioeconomy Science Limited (2026)

tensions around retreat protocols, collective tenure, or Māori data sovereignty (Ministry for the Environment 2024; 2025g).

Some delivery is under way through regional partnerships and Māori-designed pilots. Any broader uptake depends on legislating tikanga-based retreat protocols, securing standing funding for kāinga regeneration, and recognising Māori authority in spatial and infrastructure decisions (Expert Working Group on Managed Retreat 2023; Stephenson, Kawharu et al. 2023). Risks of design lock-in are high when relocation happens under market, or individual-title models that fracture whakapapa ties and ahi kā (Rout & Walker 2021; Pirini 2024). Coordination across scales is improving in places, yet remains inconsistent across coastal hazards, housing, heritage, transport and emergency systems. Engagement quality is important: mana-enhancing processes that centre wāhine and rangatahi sustain tikanga transmission; but transactional consultation adds burden to Māori without shifting outcomes (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Policy readiness would increase with mandated co-governance, Māori-controlled data systems to track cultural sites and practices, and long-term finance tailored to collective tenure and intergenerational obligations (Rout & Whitehead 2023; Sharma et al. 2024; Walker et al. 2025).

4.5.3 Policy shortfall

Even if the current policy suite were fully delivered, a substantial residual risk would remain. While these measures may lower exposure at specific sites and improve procedures, they still do not secure the continuity of tikanga, te reo, and whakapapa across the places and time frames at risk. Where tikanga-based retreat is not legislated, relocation processes can still sever ahi kā, weaken whanaungatanga and undermine hapū/iwi governance (particularly in low-lying coasts and erosion-prone river valleys) (Rout & Walker 2021; Stephenson, Kawharu et al. 2023; Bailey-Winiata et al. 2024). If Fast-track approvals proceed without explicit tikanga safeguards and recognition of Māori decision-rights, accelerated consents could heighten residual risk to hapū identity, especially where projects intersect with coastal hazard zones, wāhi tapu, or mahinga kai, widening the policy shortfall for managed retreat and wāhi tapu protection (Ministry for the Environment 2025a; 2025b). Demographically, wāhine Māori bear disproportionate impacts when caregiving, cultural transmission and precarious labour prospects are intensified by displacement or by infrastructure-led adaptation that excludes Māori leadership; and urban Māori, distant from papakāinga and often outside iwi-based funding logics, face persistent barriers to reconnection (Ratana 2023; Rua et al. 2023). Economically and institutionally, marae, kāinga and urupā remain difficult to insure and undervalued in recovery, leaving identity-critical assets exposed even where hazard works proceed (Whitehead & Walker 2021).

Full implementation of current policy would not eliminate principal drivers such as sea-level rise, coastal erosion or climate-driven ecosystem shifts; nor would it resolve legacy governance constraints in tenure, insurance and planning that fragment collective decision-making. Time lags further compound risk: benefits from site works or housing projects may arrive after relational thresholds, continuity of use, language, and caregiving roles have been crossed (Tapsell 2022; Yletyinen et al. 2022; Apiti et al. 2023). While RMA national-direction changes could narrow the shortfall if they embed Te Tiriti-consistent criteria (for example, co-governance), they could also entrench it if “interests of all water users” are prioritised without co-governance and mātauranga-based limits (Ministry for the Environment 2025d).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Until the form of the national adaptation framework is settled, and decisions on cost-sharing, retreat powers, and tikanga-based metrics are known, the identified gaps in law, finance and data governance persist, leaving tikanga transmission exposed to cumulative loss (Ministry for the Environment 2025e; 2025f). Likewise, the Government's climate strategy and work programme, while signalling a "fair and enduring adaptation system," do not by themselves prevent procedural inclusion but substantive exclusion. Without enabling statutes and funding tailored for Māori communities, the shortfall remains materially unchanged (Ministry for the Environment 2024; 2025g).

Key barriers to policy readiness in this area include a lack of Te Tiriti-consistent mandates; of long-term finance for kāinga regeneration; of insurance and recovery settings for collective assets; and lack of Indigenous data infrastructure. Without them, agencies delivering the policy can't learn or adjust quickly, and Māori identity loss builds over time (Erueti et al. 2023; Rout & Whitehead 2023; Sharma et al. 2024). Gaps that would narrow the shortfall include: i) legislating tikanga-based retreat protocols (Expert Working Group on Managed Retreat 2003); ii) establishing a Māori Resilience Fund with relational accountability (Berghan 2001); iii) investing in marae-centred, kaupapa Māori housing and place-based infrastructure (māra kai, pātaka kai, marae, papakāinga, and puna) (Andersen 2024); iv) embedding mātauranga Māori principles and indicators in statutory planning (Rout & Whitehead 2023); v) building wāhine-led leadership and care networks as core adaptation capacity (Tai-o-Rongo Research Collective 2024).

Adaptation limits and tipping points are foreseeable. Under higher-warming pathways, repeated inundation, accelerated erosion and taonga species loss may exceed the capacity of site-by-site measures, especially where governance remains non-Te Tiriti-consistent. Institutional thresholds can be crossed when relocation proceeds without Māori authority or when insurance and compliance regimes render collective stewardship untenable or homes unliveable. Once whakapapa to a place is sufficiently broken (through loss of marae or urupā use, cessation of ahi kā, or sustained barriers to reconnection) identity formation and intergenerational learning can decline rapidly and become difficult to restore (Munro 2021; Kawharu 2023; Andersen 2024). Residual risks fall disproportionately on Māori communities and whenua Māori, where exposure co-locates with under-resourcing, governance misalignment, and historic dislocation. Narrowing the shortfall requires structural shifts in law, finance, insurance, data, and planning, so that tikanga, mana motuhake, and hapū/iwi identity are not treated as an afterthought but as the organising logic of adaptation (Tapsell 2022; Erueti et al. 2023; Rout et al. 2025).

4.5.4 Overall assessment

Table 28 summarises policy readiness for this risk. Ratings range from *Insufficient* to *Significant gaps*.

Policy coverage is patchy: most instruments recognise Māori interests but stop short of mandating Te Tiriti–based governance or tikanga-based planning at scale. Key system levers (e.g., a Climate Adaptation Act and the Adaptation Framework) are undeveloped, RMA national-direction changes are uncertain, and Fast-track accelerates projects without explicit tikanga safeguards, leaving wāhi tapu, marae, and kāinga exposed. Readiness to deliver is strongest in Māori-led initiatives (kāinga regeneration, marae-led planning, disaster response). However, state-system readiness is fragmented: roles are blurred across agencies, funding is intermittent and misaligned with collective tenure, participation windows can be compressed, and regional practice varies. Consequently, even full delivery of the current suite would leave substantial residual risk to tikanga, whakapapa, and ahi

© New Zealand Institute for Bioeconomy Science Limited (2026)

kā, as climate drivers and legacy governance/insurance constraints persist and time lags push communities past relational thresholds.

Overall readiness: *Insufficient*. The system is not yet Te Tiriti-consistent or reliable enough to safeguard tikanga and hapū/iwi identity nationwide.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 28: Policy readiness assessment for disruptions to tikanga and hapū/iwi identity

Dimension	Rationale	Score
Policy coverage	Coverage exists across recognition-level instruments and emerging guidance, but key mandates are missing. The proposed Climate Adaptation Act has not been introduced; the national adaptation framework is still in development; RMA national-direction changes are uncertain; Fast-track Act prioritises delivery speed without explicit tikanga-based governance safeguards. Strong Māori-led exemplars exist but remain peripheral to state systems. Overall, important aspects of the risk (Te Tiriti-based governance, tikanga-based planning at scale, protection for wāhi tapu/kāinga during retreat) are not yet well covered.	Significant gaps
Readiness to implement/deliver	Delivery capacity is strong in Māori-led initiatives, but state-system readiness is uneven: roles/responsibilities remain blurred across agencies; funding is intermittent and misaligned with collective tenure; transitional reliance on the current RMA creates regional variability; Fast-track Act compresses participation windows; the proposed adaptation framework settings are not yet settled. These indicate major delivery shortfalls and fragmentation.	Significant gaps
Policy shortfall	Even with full implementation of the current suite, substantial residual risk to tikanga, whakapapa, ahi kā, and hapū/iwi identity would remain (e.g., non-legislated tikanga-based retreat, insurance/valuation gaps for marae and urupā, accelerating hazards, time-lag effects, and foreseeable adaptation limits). Without structural shifts in law, finance, insurance, data governance and co-governance, major parts of the risk remain unaddressed.	Extreme
Overall readiness	Taken together, patchy coverage, major delivery shortfalls, and substantial residual risk, the current system does not yet provide a reliable or Te Tiriti-consistent pathway to safeguard tikanga and hapū/iwi identity nationwide.	Insufficient

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.6 Loss of Indigenous knowledge systems

4.6.1 Policy coverage

Across Aotearoa, policy settings affecting mātauranga Māori fall into three layers: direct, indirect, and enabling. However, collectively, these policies recognise rather than secure the conditions for intergenerational transmission. National policy instruments acknowledge mātauranga Māori yet stop short of creating Te Tiriti-based mandates or statutory pathways for hapū-led planning: the Government's proposed national adaptation plan references mātauranga without operational mechanisms, and the proposed Climate Adaptation Act has not yet been introduced (as at October 2025) (Expert Working Group on Managed Retreat 2023; Rout et al. 2025).

The Government's climate strategy affirms adaptation as a priority workstream, signalling alignment with a refreshed adaptation framework and broader climate programme, but it sets high-level intent rather than detailed, enforceable requirements for mātauranga-based planning and monitoring (Ministry for the Environment 2024; 2025e). The proposed adaptation framework outlines a national architecture for roles, principles and planning cycles and was released alongside an independent adaptation report, creating a window in which to embed Māori-informed indicators and Māori decision-making requirements. However, most policy remains programmatic rather than binding at this stage (Ministry for the Environment 2025a; 2025f; 2025g).

Locally, some councils have begun to weave maramataka and tohu into climate and land-use planning. However, inconsistent resourcing and the absence of binding frameworks mean mātauranga Māori is treated as a "nice-to-have" add-on rather than a decision-making requirement. (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Stephenson, Kawharu et al. 2023). In contrast, Māori-led programmes provide direct, implementation-ready models eg, Tai-o-Rongo (maramataka) (Tai-o-Rongo Research Collective 2024); Taura Kuku and Kohunga Kūtai projects (biodegradable spat mussel lines) (Paul-Burke et al. 2022; Skelton et al. 2023); and kāinga-based initiatives (Berghan 2021).

Two current/recent reform tracks could affect coverage. First, the Fast-track Approvals Act 2024 has established a parallel, time-bound consenting pathway with Ministerial referral to expert panels (and specified decision time frames). While designed to accelerate "beneficial" projects, its relationship to local plan provisions and existing national direction will shape whether mātauranga Māori, wāhi tapu, and tikanga-based conditions are consistently required in panel decisions. At present, its current guidance describes processes rather than explicit mātauranga safeguards (Ministry for the Environment 2025c; 2025d).

Second, the Government's RMA reform work programme and consultation on updating national direction could either hard-code or dilute provisions relevant to mātauranga Māori (e.g., sediment controls, habitat protection, intergenerational outcomes). June 2025 resource management reform updates and the national-direction consultation indicate change is under way, but specific Te Tiriti-consistent, mātauranga Māori-anchored directives are not yet confirmed (Ministry for the Environment 2025b; 2025h).

Indirect levers, such as hazard management, biodiversity, and heritage regimes, could reduce pressures on wāhi tapu and taonga species if applied through Te Tiriti-consistent co-decision making. The review of the Environmental Reporting Act 2015 created an opening to co-design mātauranga indicators for national reporting. However, a cohesive policy approach has not yet been implemented. The national adaptation framework proposals and the Government climate-change programme together signal an intention to coordinate policy across sectors, but in their

© New Zealand Institute for Bioeconomy Science Limited (2026)

current form, they remain enabling rather than directive for mātauranga Māori (Ministry for the Environment 2025a; 2025e; 2025g).

Enabling foundations exist but remain thin: kaupapa Māori indicator frameworks and the Mauri Model show how mātauranga Māori can be formalised without losing integrity (Morgan et al. 2021); tohu-based surveillance offers climate-relevant monitoring (Wilcox et al. 2024); and Māori data-sovereignty architectures outline how knowledge and environmental data can be governed for trusted uptake (Sharma et al. 2024). For scale and urgency, the current tools do not match the pace of ecological change and site loss that undermines in-situ learning; and risks to knowledge continuity are already material where species, landscapes, and wānanga spaces are degraded (Awatere et al. 2021; Tapsell 2022).

Overall, coverage is present but patchy. It is strong in Māori-led exemplars and exploratory guidance, moderate in emerging national frameworks, and weak where fast-track and RMA settings do not yet require mātauranga Māori as a governing logic for planning, monitoring, and investment (Expert Working Group on Managed Retreat 2023; Ministry for the Environment 2025c; 2025h; 2025g; Rout et al. 2025).

4.6.2 Readiness to implement or deliver

Delivery is feasible where Māori-designed vehicles exist, but uneven within Crown systems. Communities are already implementing maramataka-aligned training, tohu monitoring, tikanga-based design, and kāinga regeneration that translate knowledge protection into land-use, housing, and environmental decision-making (Berghan 2021; Hall et al. 2024; Wilcox et al. 2024). Nevertheless, roles and responsibilities remain blurred nationally: climate, heritage, biosecurity, education, and emergency management mandates seldom embed Te Tiriti principles, producing procedural inclusion without epistemic authority (Erueti et al. 2023; Rout et al. 2025). Funding is intermittent and compliance-heavy; grants and insurance seldom recognise marae, kāinga, urupā, or wānanga as core adaptation infrastructure, and eligibility rules are often a misfit for Māori governance (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Resilience to Nature’s Challenges 2024a).

The proposed national adaptation framework sketches clearer system roles and iterative planning cycles, which could improve readiness by specifying who leads, who co-decides, and how monitoring ties to investment; but until translated into statute, mandates and baselines for mātauranga Māori remain aspirational (Ministry for the Environment 2025a; 2025g). The Government’s climate strategy and work programme provide intent but do not (on their own) confer legal authority or dedicated funding streams for mātauranga Māori transmission (Ministry for the Environment 2024; 2025e).

Technical and human capability is strong within whānau, hapū, and iwi, particularly via wāhine and kaumātua leadership, but this capacity is eroded by underinvestment and the administrative load of navigating systems that treat mātauranga Māori as supplementary (Cram 2021; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Some delivery is under way through local partnerships and Māori-led pilots; broader uptake will depend on legislating tikanga-based protocols (including those for managed retreat), establishing standing finance for mātauranga Māori transmission and kāinga regeneration, and recognising Māori authority in spatial planning and monitoring (Expert Working Group on Managed Retreat 2023; Stephenson, Kawharu et al. 2023).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Readiness is also shaped by reforms external to adaptation: the Fast-track Approvals Act 2024 could speed delivery of place-based projects that include mātauranga Māori components if project selection, panel direction, and conditions explicitly require Te Tiriti-consistent assessment and mātauranga Māori-grounded mitigation. However, without such requirements, readiness to protect knowledge may be weakened where fast-tracked pathways sidestep local provisions that have been carrying mātauranga Māori practice into consents (Ministry for the Environment 2025c; 2025d). Similarly, updating the national direction of the RMA offers a gain in readiness if sediment reduction, habitat improvement and tikanga-based outcomes are hard-coded with mātauranga Māori monitoring requirements. However, if updates narrow or defer these elements, readiness will remain contingent on ad-hoc local arrangements (Ministry for the Environment 2025b; 2025h).

Mātauranga Māori frameworks, including Mauri-based assessment, tohu networks, and Māori-controlled data platforms, are available, but current technocratic approaches risk marginalising te ao Māori approaches to managing data (Morgan et al. 2021; Sharma et al. 2024). Coordination across sectors is variable, and engagement quality is determinative: mana-enhancing processes that put wāhine and rangatahi at their heart, sustain knowledge transmission; transactional consultation expends community effort without shifting outcomes (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Tai-o-Rongo Research Collective 2024).

Overall, our current analysis indicates a moderate readiness where Māori-led practice already operates, emerging system-level readiness if the adaptation framework is implemented with enforceable co-decision making and indicator provisions, and uncertain readiness where fast-track and RMA reform settings do not require mātauranga Māori in approvals and compliance (Ministry for the Environment 2025a; 2025c; 2025h).

4.6.3 Policy shortfall

Even if current policies, plans, and signalled actions were fully implemented, a substantial residual risk would remain. The present mix could reduce exposure for selected sites, lift procedural recognition, and scale some monitoring and training. However, it does not yet secure the ecological, spatial, and governance conditions that keep mātauranga Māori alive under conditions where species are in decline, landscapes shifting, and communities face relocation. Climate-forced changes to taonga species, maramataka-relevant rhythms, and knowledge sites are only partially within policy control; time lags in ecosystem recovery and in building new wānanga mean cultural thresholds can be crossed before benefits arrive (Tapsell 2022; Apiti et al. 2023; Short et al. 2023).

Geographically, coastal and river-valley communities with accelerating erosion and inundation face persistent loss of mātauranga connected to those sites: demographically, residual risks fall disproportionately on wāhine Māori who shoulder care and transmission roles yet are structurally distant from support mechanisms (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Ratana 2023; Bailey-Winiata et al. 2024). Marae, kāinga, urupā, and wānanga are hard to insure and undervalued in recovery, leaving mātauranga Māori connected infrastructure exposed, even when hazard works proceed (Whitehead et al. 2023).

Full implementation of policy would not, on its own, resolve core drivers such as ecological change, epistemic exclusion, and misaligned finance and data systems. Key barriers (including Te Tiriti-consistent mandates for Māori authority, long-term funding for hapū/iwi led climate adaptation, valuation and insurance settings for Māori assets, and Māori-governed data infrastructures) have not yet been structurally addressed by central government (Erueti et al. 2023; Sharma et al. 2024; Rout et al. 2025). From the current government work programme, the following three specific shortfalls will remain unless further steps are taken.

© New Zealand Institute for Bioeconomy Science Limited (2026)

1 The national adaptation framework and emerging climate strategy need translation into statutory duties and funding lines that make mātauranga Māori-based monitoring and Māori decision-making unavoidable in plans and investments (Ministry for the Environment 2024; 2025a; 2025e; 2025g).

2 Fast-tracked processes will require explicit, enforceable criteria for Te Tiriti-consistency and need to include mātauranga Māori in project selection, panel directions and consent conditions to avoid bypassing cultural safeguards often located in local instruments (Ministry for the Environment 2025c; 2025d)

3 Any RMA national-direction updates must include sediment reduction and habitat protections along with mātauranga Māori monitoring to address the upstream drivers that erode knowledge sites, rather than relying on discretionary uptake (Ministry for the Environment 2025b; 2025h).

Additional actions that would narrow the gaps in implementation include legislating a national, tikanga-based framework that recognises mātauranga as a governing system; establishing a Māori Resilience Fund co-designed with iwi and hapū; embedding maramataka and tohu in statutory planning and monitoring; investing in knowledge places (māra kai, pātaka kai, puna wai, kāinga) and digital archiving under Māori data sovereignty; and resourcing wāhine and kaumātua leadership as core transmission capacity (Berghan 2021; Rout & Whitehead 2023; Tai-o-Rongo Research Collective 2024; Wilcox et al., 2024; Wood et al. 2024). Under higher-warming pathways, repeated habitat loss, site damage, and displacement may push some knowledge systems beyond viability in in situ practice if governance remains non-Te Tiriti-consistent. Once ahi kā is interrupted, species-anchored practices lapse, or places for learning may be lost without resourced reconnection, the decline in intergenerational transmission can accelerate and become hard to reverse (Yates 2021; Hall et al. 2024).

In terms of distribution, residual risks concentrate in Māori communities and whenua Māori, where exposure coincides with under-resourcing and a governance misfit. Closing the shortfall will require shifting from recognition to authority: embedding mātauranga Māori, under Māori control, as the organising logic of adaptation law, finance, monitoring, and design (Expert Working Group on Managed Retreat 2023; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Rout et al. 2025). It will also require national-direction settings that make mātauranga Māori non-discretionary (Ministry for the Environment 2025a; 2025b; 2025g).

4.6.4 Overall assessment

Table 29 summarises policy readiness for this risk. Ratings range from *Insufficient* to *Moderate gaps.*

Current policy recognises mātauranga Māori but rarely requires it as the organising logic for planning, investment, monitoring, or approvals. National signals, the Government's climate strategy and the proposed adaptation framework set intent and system architecture yet remain enabling rather than binding. In contrast, the signalled Climate Adaptation Act has not materialised (as of October 2025). Locally, some councils are embedding maramataka and tohu, and Māori-led programmes (e.g., initiatives by Tai-o-Rongo Research Collective (2024), taura kuku, kohunga kūtai) all demonstrate practical delivery pathways. However, uptake is uneven, resourcing is inconsistent, and legal mandates are unclear. Readiness is moderate in areas where Māori-designed vehicles are already operational, thanks to strong community capability. However, the system-wide implementation stalls due to several factors, including blurred roles, intermittent

funding, insurance/valuation settings that do not align with marae, kāinga, urupā, and wāhi tapu, and the lack of statutory authority for hapū/iwi.

Two reform tracks are key to further progress Māori climate adaptation approaches: the Fast-track Approvals Act 2024 could either embed Te Tiriti-consistent assessment and mātauranga-grounded conditions, or bypass local safeguards. Similarly, any RMA national-direction updates could embed habitat protections and mātauranga Māori monitoring or dilute them. Even with the full implementation of today's statutory instruments, a significant residual shortfall remains because of ecological change, time lags, and the loss of knowledge outpaces current tools.

Overall readiness *Insufficient*. Closing the policy gap requires translating the adaptation framework and climate programme into statutory duties and funding lines that make Māori decision-making and mātauranga-based indicators non-discretionary, plus enforceable Fast-track Act criteria, strengthened national direction, a tikanga-based national framework, a Māori Resilience Fund, investment in knowledge places and sovereign digital archiving.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 29: Policy readiness assessment for loss of Indigenous knowledge systems

Dimension	Rationale	Score
Policy coverage	Coverage includes various approaches but is primarily recognition focused. References to the national adaptation plan lack enforcement; the proposed Climate Adaptation Act has not been introduced as of October 2025. The government's adaptation framework and climate strategy are non-binding and programmatic. Local maramataka/tohu use is inconsistent, and while there are Māori-led examples, they are not systematised. Fast-tracking may overlook safeguards; RMA direction is still undecided. Enablers are present but lack support.	Significant gaps
Readiness to implement/deliver	Delivery is feasible where Māori-designed vehicles are in operation (maramataka training, tohu monitoring, tikanga-based design, kāinga regeneration). Blurred roles, intermittent funding, misalignment of insurance and eligibility, and non-statutory mandates constrain system readiness. The adaptation framework could lift readiness if legislated for (i.e., by including co-decision making, indicators, and monitoring investment). Māori climate platform lacks funding. Māori capability is strong yet under-resourced. Fast-track/RMA shifts can raise or lower readiness.	Moderate gaps
Policy shortfall	A considerable risk persists. Ecological change, time-lags, and loss of knowledge all erode in situ transmission. Impacts concentrate on wāhine Māori and under-resourced communities. Marae/kāinga/urupā are hard to insure and undervalued. Structural barriers, Te Tiriti-consistent authority, sustained funding, valuation/insurance for relational assets, and Māori-governed data remain unresolved. Needed: statutory duties/funding for indicators and Māori decision-making, a tikanga-based framework, and targeted investments.	Extreme
Overall readiness	The current system shows patchy coverage and a significant shortfall in securing intergenerational mātauranga Māori. Māori-led practices demonstrate moderate readiness, but there is no systemic support. Improvement requires binding, Te Tiriti-aligned mandates, sustainable funding for regeneration, and statutory mātauranga indicators. Fast-tracking and RMA reforms are crucial; without alignment to Māori rights, issues will continue.	Insufficient

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.7 Legal exclusion and governance failures

4.7.1 Policy coverage

Current coverage is partial and mainly enabling, with few direct levers that embed Māori authority in climate governance. National strategies and inquiries increasingly acknowledge Māori roles. Nevertheless, they stop short of creating binding, co-equal powers for iwi and hapū in adaptation, emergency management, and land-use decision-making.

New Zealand's National Adaptation Plan (NAP) recognises Māori interests, but in practice it relies on consultation rather than shared authority, and co-governance provisions are rare, uneven, and vulnerable to political change (Tapsell 2022; Kawharu 2023). The proposed national adaptation framework signals a system architecture for adaptation (principles, roles, monitoring), but, at the consultation stage, its provisions are programmatic rather than binding and do not yet establish co-jurisdictional authority for iwi and hapū (Ministry for the Environment 2025a; 2025g). Similarly, the Government's release of an independent adaptation report and associated work programme recognises the need for system change but does not itself alter statutory powers (Ministry for the Environment 2025e; 2025f).

Where Māori-led or co-designed approaches have been attempted, they tend to operate as pilots or discretionary partnerships rather than legislated norms. Initiatives for regenerating papakāinga and kāinga receive modest policy recognition but demonstrate clear, place-based benefits; however, these initiatives are not yet treated as core climate infrastructure across planning systems or backed by durable statutory mandates or finance pathways (Andersen 2024; Berghan 2021). The Government's climate strategy outlines the overall programme but does not itself confer decision-making powers; instead, its emphasis is on guidance rather than jurisdictional, and it defers detail to subsequent frameworks and statutes (Ministry for the Environment 2024, 2025e).

On the ground, iwi-led emergency responses after Cyclone Gabrielle, including coordinated welfare and logistics by Ngāti Kahungunu, show that Māori institutions already deliver direct risk reduction. However, these contributions sit largely outside formal authority and funding settings. They therefore function as indirect or enabling measures rather than as embedded pillars of the emergency system (Bush International Consulting 2024; Cram 2021). Catchment co-governance experiments, such as Waiapu Kōkā Huhua in the Waiapu Catchment, Gisborne (see Pohatu et al. 2021), integrate whakapapa-based governance with environmental science and point to scalable models. Nevertheless, they remain exceptional and contingent on local relationships rather than guaranteed by law (Pohatu et al. 2021).

Reform signals are emerging. The Government Inquiry into Severe Weather Events (Department of Internal Affairs 2024) and the Ministerial Inquiry into Land Use (2023) both recommend Te Tiriti-consistent governance with stronger Māori decision-making roles. The Expert Working Group on Managed Retreat (2023) sets out tikanga-informed pathways. However, the proposed Climate Adaptation Act has not yet embedded those roles, and emergency management reforms still place Māori in advisory positions rather than co-jurisdictional ones. As a result, today's coverage is primarily enabling or indirect; it lacks clear, direct levers that match the scale and urgency of escalating climate risk, especially under high-emissions scenarios to 2090.

Two parallel reform streams shape coverage, and have mixed implications. First, the Fast-track Approvals Act 2024 created an expedited, ministerially-gated consenting pathway for nationally significant projects (Ministry for the Environment 2025c; 2025d). While this may accelerate infrastructure delivery, its compressed time frames and centralised discretion can narrow

© New Zealand Institute for Bioeconomy Science Limited (2026)

opportunities for iwi and hapū to exercise rangatiratanga and mana whakahaere within consent processes unless explicit Te Tiriti tests and co-governance requirements are built into project selection, conditions, and monitoring. Second, resource management reform activity signals updates to national direction (e.g., potential revisions across National Policy Statements/National Environmental Statements) and a continuing reform timetable (Ministry for the Environment 2025b; 2025h). These levers could improve coverage where national direction specifies Māori participation in plan-making, consent conditions, and freshwater/estuary objectives; equally, if updates remain consultative rather than co-jurisdictional, coverage will continue to be enabling rather than direct.

Neither of these streams presently guarantees Māori-governed data, indicators, or mātauranga Māori integration as decision-standards; these remain dependent on local arrangements and council practice, producing uneven geographic coverage across urban and rural contexts. Overall, current policy coverage recognises Māori roles but does not yet match the scale and urgency of escalating climate risk under high-emissions scenarios to 2090, particularly where collectively owned whenua, marae, urupā, and marine interests are affected (Ministry for the Environment 2024; 2025a; 2025b; 2025c; 2025d; 2025e; 2025g).

Geographic coverage by policy is patchy: urban and rural Māori face different but compounding gaps in authority and resourcing, and the absence of binding co-governance undermines alignment with the best available science and with long-term adaptation needs (Erueti et al. 2023; Rout et al. 2025).

4.7.2 Readiness to implement or deliver

Delivery capacity is uneven and depends heavily on voluntary labour, short-term grants, and goodwill rather than on clear mandates and base funding. Roles and responsibilities for Māori in emergency, adaptation, and infrastructure decisions are inconsistently defined across agencies, which leads to ad hoc engagement, duplication, and consultation fatigue. Even where councils seek to partner with iwi, the lack of legal authority, multi-year funding, and Māori data sovereignty tools all constrain implementation and slow decision-making. Technical capacity within Māori organisations is strong, as demonstrated by iwi-led response logistics, kaupapa Māori housing, and catchment governance, but these efforts are routinely under-resourced and must navigate processes designed for individual property owners and central government accountability rather than collective governance and whakapapa obligations (Papa Pounamu 2022; Kawharu 2023; Andersen 2024; Bush International Consulting 2024; Sharma et al. 2024).

Readiness is most advanced where existing Māori institutions align with an agreed statutory role, stable funding, and measurable outcomes. The proposed national adaptation framework could lift readiness by clarifying system roles, embedding monitoring, and connecting local planning to national objectives. However, at the current proposal stage, it does not yet specify binding co-governance mechanisms, sustained resourcing for iwi/hapū authorities, or for Māori-governed data platforms to operationalise mātauranga Māori as evidence standards (Ministry for the Environment 2025a; 2025g). The Government's climate strategy/work programme coordinates actions across portfolios, which can improve cross-agency delivery. However, without explicit mandates for Māori co-jurisdiction, it risks reproducing advisory-only roles (Ministry for the Environment 2024; 2025e). Fast-track consenting introduces additional delivery pathways for projects but compresses time frames for participation and increases reliance on ministerial discretion; unless early-stage project selection criteria include enforceable Te Tiriti tests and resourced Māori assessment, practical readiness for Māori decision-making can be reduced rather than improved (Ministry for the Environment 2025c; 2025d). By contrast, targeted updates to the national direction of resource management could improve readiness if they require councils to involve iwi/hapū authorities in

© New Zealand Institute for Bioeconomy Science Limited (2026)

plan-making and consenting, provide templates for Māori-led monitoring/conditions, and tie funding to demonstrated co-governance practice (Ministry for the Environment 2025b; 2025h).

Delivery is already underway (such as marae-led disaster coordination and co-management in select catchments), demonstrating proof of concept. However, the absence of binding co-governance clauses, ring-fenced funding, and Māori-controlled monitoring systems constrains scale-up. Policies are sometimes not created to incorporate mātauranga Māori or iwi data platforms, so systems become stuck in Crown-set ways of working. Coordination across government remains variable, with procedural inclusion but limited power-sharing. Wāhine Māori and other frequently mobilised community leaders are seldom resourced or mandated as delivery partners despite their documented leadership in climate response and recovery (Tapsell 2022; Erueti et al. 2023; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Stephenson, Kawharu et al. 2023).

4.7.3 Policy shortfall

Even if current policies, plans, and signalled reforms were fully implemented, substantial residual risk would remain because the central driver of vulnerability, the lack of statutory recognition of Māori authority, would persist in many domains. Without legislated co-governance, mana whakahaere over managed retreat, emergency powers, land-use change, and funding decisions remains precarious, leaving Māori exposed to procedural exclusion and maladaptive outcomes that displace communities from culturally significant lands and sever ahi kā. Large portions of the risk, including collectively owned whenua, marae infrastructure, and Māori marine interests, remain weakly covered by eligibility and valuation rules built for individual title and market logistics. These design choices reproduce barriers to finance, insurance, and recovery, and leave governance thresholds vulnerable to being breached during high-impact events or under faster warming pathways to 2090 (Whitehead et al. 2021; Expert Working Group on Managed Retreat 2023; Ministerial Inquiry into Land Use 2023; Pirini 2024).

Specific shortfalls arise within each current policy lever. The central government's climate strategy and work programme sets the intent but lacks enforceable powers; residual risk remains where co-governance is not mandated in funding rules, infrastructure prioritisation, or adaptation planning (Ministry for the Environment, 2024; 2025e). The proposed national adaptation framework, while promising for system alignment, would leave gaps unless it establishes Māori planning authorities with devolved powers, long-term funding, and Māori-governed indicators that integrate mātauranga Māori alongside Western science in statutory monitoring (Ministry for the Environment 2025a; 2025g). Fast-track pathways could deepen exclusion of Māori, if compressed timelines and centralised discretion override iwi/hapū decision-making or bypass plan-level commitments; absent binding Te Tiriti consistency and consent conditions co-set with Māori authorities, significant residual risk remains (Ministry for the Environment 2025c; 2025d). Resource management reform and an updated national direction can help close some gaps, but only if they transition from consultation-based participation to co-jurisdictional requirements embedded in plans, consents, and enforcement (Ministry for the Environment 2025b; 2025h).

Key barriers, such as fragmented mandates, the reliance on technocratic measures, and the absence of Māori data sovereignty in statutory monitoring, are only partially addressed by current initiatives. To close the policy shortfall, reforms need to move from consultation to co-jurisdiction. They should include binding co-governance clauses across adaptation and emergency statutes, as well as devolved Māori planning authorities with secure, multi-year funding. Māori-led relocation protocols and kāinga regeneration should be treated as core infrastructure. They should also include accredited decision systems that integrate mātauranga Māori alongside Western science

© New Zealand Institute for Bioeconomy Science Limited (2026)

through Māori-governed data platforms. Without these shifts, foreseeable adaptation limits will be reached when repeated emergencies exhaust voluntary systems, trust erodes, and governance saturation leads to disengagement. The residual risks from reaching these limits will fall disproportionately on Māori communities and whenua Māori despite incremental policy progress (Papa Pounamu 2022; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023; Stephenson, Kawharu et al. 2023; Sharma et al. 2024; Rout et al. 2025). The Government's independent adaptation report (Ministry for the Environment 2025f) underscores consensus on systemic change. However, until its recommendations are translated into statute and national direction, material shortfalls will remain.

4.7.4 Overall assessment

Table 30 summarises policy readiness for this risk. Ratings range from *Insufficient* to *Significant gaps*.

Policy settings essentially recognise Māori interests but do not confer durable, co-equal decision-making powers. Where Māori-led delivery is strong (e.g. for marae-based emergency logistics, catchment governance), it operates well despite the system, relying on voluntary labour and short-term grants. Fast-tracking consenting compresses participation windows and relies on ministerial discretion. Resource management reforms could improve performance –but only if national direction embeds co-jurisdictional roles and mātauranga Māori-informed standards. The proposed national adaptation framework may improve clarity and monitoring, but without binding mandates, ring-fenced finance, and Māori-governed data platforms, residual risk remains high.

Geographic coverage of policy readiness is uneven: urban Māori face housing and infrastructure constraints, while rural and coastal communities bear compounded erosion and flood risks. Near-term gains in policy readiness (2025–2030) are possible via strengthened national direction and funding baselines, but only with enforceable roles and transparent accountability.

Overall readiness: *Insufficient.* To enhance readiness, we believe policy ought to include co-governance clauses into adaptation, emergency, and consent laws. This would involve devolving powers to Māori planning authorities with long-term funding, treating kāinga regeneration and relocation protocols as essential climate infrastructure, and requiring accredited indicators that incorporate mātauranga Māori alongside Western science in planning, consenting, and emergency management. Without these changes, advisory-only roles will persist, procedural exclusion will continue, and foreseeable adaptation limits will be reached as repeated events exhaust voluntary systems and erode trust, leaving disproportionate residual risk for Māori communities and whenua Māori under high-emissions scenarios by 2090.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 30: Policy readiness assessment for legal exclusion and governance failure

Dimension	Rationale	Score
Policy coverage	Coverage is mainly enabling and consultative. National strategies acknowledge Māori roles, but binding co-governance and co-jurisdiction are rare and uneven. Fast-track consenting risks narrowing rangatiratanga unless Te Tiriti tests are embedded. Resource management reforms could improve coverage if national direction specifies Māori participation and mātauranga Māori standards; otherwise, gaps persist. Current policy recognises needs but do not match the scale/urgency of escalating climate risks for whenua Māori and kāinga.	Significant gaps
Readiness to implement/deliver	Delivery relies on voluntary labour, short-term grants, and goodwill rather than stable mandates and base funding. Governance roles and responsibilities for Māori across emergency management, adaptation, and infrastructure are inconsistently defined, causing duplication and fatigue. Proof-of-concept exists (e.g., in marae planning, catchment co-governance). However, scale-up is constrained by missing co-authority, ring-fenced finance, and Māori-governed data systems to put mātauranga Māori in place in monitoring and consent conditions.	Significant gaps
Policy shortfall	Even with full implementation, residual risk remains high because statutory recognition of Māori authority is not secured. Advisory-only roles leave iwi/hapū exposed to procedural exclusion, maladaptation, and displacement from culturally significant places. Fast-track pathways and technocratic measures compound gaps. Without co-governance clauses, devolved Māori planning authorities, and Māori-controlled indicators and data platforms, significant risk remain unaddressed to 2090.	Extreme
Overall readiness	Given significant coverage and delivery gaps and an insufficient shortfall profile, overall readiness is low. Existing policy signals and pilots demonstrate potential, but lack binding levers, long-term funding, and accredited decision systems that seat mātauranga Māori alongside Western science. Readiness will rise only if the national direction of resource management and the national adaptation framework mandate co-authority, resource Māori authorities, and require Māori-governed data and monitoring across planning, consenting, and emergency powers.	Insufficient

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

4.8 Increased health vulnerabilities

4.8.1 Policy coverage

Aotearoa's current policy architecture relevant to climate-related health vulnerabilities for Māori sits across health system reforms, the National Adaptation Programme (NAP), emergency management, housing quality and supply, drinking water and wastewater regulation, environmental management, and social protection. Taken together, these instruments create direct, indirect, and enabling levers that shape exposure, sensitivity, and adaptive capacity. Direct levers include minimum standards for warm, dry, energy-safe homes and safe water, and service models for primary and community care that can mitigate cardio-metabolic and respiratory risk when hazards intensify (Su & Wu 2020; Hughes et al. 2021). Indirect levers include land-use and infrastructure decisions that shape the distribution of hazards and the resilience of critical infrastructure and essential services over time (Pourzand et al. 2023). Enabling levers include data, workforce, and investment settings intended to support local planning and Māori-led service delivery (Masters-Awatere, Young & Graham 2022; Kukutai et al. 2024).

The degree to which Te Tiriti is put into operation varies across this architecture. The Waitangi Tribunal's Health Services and Outcomes Inquiry documented persistent structural barriers to achieving equitable outcomes and emphasises Crown duties of active protection, partnership, and options in the health system (Waitangi Tribunal 2019). Pandemic findings further underscored that where Māori leadership was formally empowered and resourced, outcomes and trust improved, and where it was not, inequities deepened (McMeeking & Savage 2020; Waitangi Tribunal 2021). In the adaptation space, policy reviews identify uneven translation of commitment into measurable co-governance and co-design requirements, with Māori often positioned as consultees rather than decision makers (Masters-Awatere, Young & Graham 2022; Tapsell 2022; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). By contrast, Te Tiriti-led science-policy guidance articulates concrete mechanisms for embedding rangatiratanga, such as shared authority, distinct funding lines, and Māori data governance, highlighting what stronger coverage can look like in practice (Walter et al. 2021; Kukutai et al. 2024).

Geographically, national instruments set baselines that are mediated by regional and district delivery. This provides consistency for core protections but can leave gaps in rural and coastal districts where service reach is thin and infrastructure more brittle (Mullane et al. 2022; Tane et al. 2022). Demographically, policies increasingly name priority groups, yet practical targeting for disabled Māori, wāhine Māori, tamariki and rangatahi, and kaumātua still depend on local commissioning and transport and digital access solutions (Graham et al. 2021; Ingham et al. 2022; Jones et al. 2024). Housing and papakāinga policies illustrate this pattern: kaupapa Māori solutions such as papakāinga and small-home developments can reduce exposure to cold and damp and strengthen social support, but the land, finance, and infrastructure policy settings that enable this remain variable (Whitehead & Walker 2021; Tait-Wall et al. 2022; Andersen 2024).

Alignment with climate science is improving, but it is often calibrated to present variability more than high-end futures. Heat–health evidence and extreme rainfall attribution point to rising burdens without anticipatory action in housing, primary care, and emergency response (Harrington et al. 2023; Lai et al. 2024). Research has shown compounding mental-health and environmental-distress pathways (only partially tractable through health-sector levers alone), which signals a need for cross-sector policy integration (Hayes et al. 2018; Lawrance et al. 2022; Apiti et al. 2023).

Overall, policy coverage is meaningful but incomplete. It is strongest where Te Tiriti commitments are made operational through shared authority, sustained resourcing, and enforceable standards; where exposure-reducing regulations are implemented and monitored; and where enabling levers

© New Zealand Institute for Bioeconomy Science Limited (2026)

build capability for Māori-led planning and service continuity. It is weakest where responsibilities are spread across agencies without co-decision making; or where scale, scope, and timing are mismatched to projected risk trajectories (Waitangi Tribunal 2023; Kukutai et al. 2024).

Since mid-2024, several policy moves have recalibrated this coverage.

- The Government Policy Statement on Health 2024–2027 (Manatū Hauora 2024a; hereafter 'GPS') sets the health system's priorities and explicitly underpins the New Zealand Health Plan – Te Pae Waenga 2024–2027 of Te Whatu Ora (Health New Zealand/Te Whatu Ora 2025; hereafter 'Te Pae Waenga'). That Plan operationalises delivery expectations and performance monitoring until 2027.
- The Pae Ora (Disestablishment of Māori Health Authority) Amendment Act 2024 changes the institutional landscape for Māori health commissioning and accountability, with implications for how Te Tiriti commitments are enacted in practice.
- In March 2024, Parliament enacted the Smokefree Environments and Regulated Products Amendment Act 2024, rolling back elements of the previous smokefree package. Given the links between smoking prevalence and cardio-respiratory risk, this shift may increase pressure on prevention and clinical services in high-deprivation communities unless it is offset by other measures.

For climate, the Government's climate strategy sets system-level emissions and resilience priorities, while work to develop a fair and enduring adaptation framework is underway (Ministry for the Environment 2024). The Independent Reference Group's July 2025 advice is being considered but is not Government policy (Ministry for the Environment 2025a; 2025f). Resource-management reforms, including the Fast-track Approvals Act 2024 and consultation to update the national direction of the RMA, may alter where and how infrastructure proceeds, with potential downstream effects on hazard exposure and the location of essential services if Te Tiriti-consistent decision making and safeguards are not explicit (Ministry for the Environment 2025c; 2025d; 2025h).

4.8.2 Readiness to implement or deliver

Readiness is most reliable closest to communities, where kaupapa Māori providers, marae, and hapū/iwi organisations are empowered to utilise tikanga-grounded approaches that can be mobilised quickly during heat, smoke, flood, or contamination events. Evidence from COVID-19 and recent flood responses shows that when Māori leadership is both formally seated within command structures and suitably resourced, delivery becomes faster and more culturally safe for high-risk groups (McMeeking & Savage 2020; Boulton et al. 2022; Rout et al. 2025). Mahi aroha and locally embedded coordination sustain continuity of care and welfare when demand surges, but these strengths depend on stable commissioning, data sharing, and clarity of roles between health, emergency management, and local government (Cram 2021; Waitoki & McLachlan, 2022).

In many rohe Māori governance roles remain informal, funding cycles are short, and accountability runs vertically through agencies that are not configured for co-decision making. These conditions lead to duplication and consultation fatigue, resulting in uneven readiness during concurrent events. Workforce constraints limit capacity, particularly in rural and coastal areas where shortages in clinicians, kaiāwhina, and emergency staff intersect with hazard peaks and travel barriers (Mullane et al. 2022; Tane et al. 2022). Housing and infrastructure dependencies compound readiness (or lack of it): cold, damp homes increase baseline respiratory risk, and brittle wastewater and drinking water systems complicate safe sheltering, evacuation, and recovery (Su & Wu 2020; Hughes et al. 2021).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Institutional readiness also depends on whether policies are adaptive by design. Some policy instruments provide for iterative risk assessment, community-led planning, and learning cycles, while others lock in rigid service or capital programmes that are slow to change as hazards intensify. Reviews of adaptation policy point to gaps between intent and implementation, especially where Māori participation is framed as 'consultation' rather than as shared decision making with dedicated resources (Waitangi Tribunal 2023; Masters-Awatere, Young & Graham 2022; Tapsell 2022; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Conversely, Te Tiriti-led guidance on the interface between science and policy, and on Māori data governance, provides practical steps that increase readiness. Examples of such steps include joint commissioning mandates to Indigenous data infrastructures that allow targeted outreach without compromising rangatiratanga (Walter et al. 2021; Kukutai et al. 2024).

Digital and data factors are pivotal. Where local observation, mātauranga Māori, clinical information, and environmental monitoring are integrated, preparedness and triage become more targeted; where data sets are siloed, access restricted, or digital exclusion persists, and readiness suffers (Graham et al. 2021; Masters Awatere et al. 2024). Indigenous data sovereignty frameworks for biodiversity and health data provide models for secure sharing that can support rapid response while protecting rights (Kukutai 2024; Sharma et al. 2024).

The GPS and Te Pae Waenga clarified priorities, milestones, and reporting for 2024–2027 for the health system that should support more consistent delivery if accompanied by stable commissioning for Māori providers (Manatū Hauora 2024; Health New Zealand/Te Whatu Ora 2025). However, Health New Zealand's decision in August 2024 to cease using the Equity Adjustor Tool (a surgical wait-list algorithm that added an 'equity' score (alongside clinical need) using factors like clinical priority, time waited, location, deprivation, and ethnicity to order non-urgent surgeries") in surgical waitlists removes one mechanism that targeted persistent inequities; this may affect the system's ability to prioritise high-risk Māori populations unless alternative equity-assurance arrangements are implemented (Moir 2024). Forthcoming legal changes also shape readiness: the Mental Health Bill (which will, when it comes into force, replace the current Mental Health [Compulsory Assessment and Treatment] Act 1992) proposes a modernised, rights-based framework; until enacted and implemented, service changes remain prospective (Manatū Hauora 2024a, 2024b).

The Healthy Futures (Pae Ora) Amendment Bill, introduced in July 2025, would re-focus Health New Zealand's statutory objectives and repeal some sector principles, with implications for partnering with iwi-Māori entities and for how equity is operationalised in planning (Manatū Hauora 2025). A "system planning reset" aligning regional plans with the GPS and Te Pae Waenga is still bedding in, with timing and capacity constraints noted; these factors condition near-term readiness (Manatū Hauora 2024a).

The emerging national adaptation framework and resource-management reforms could either improve or erode policy readiness depending on how explicitly they embed Te Tiriti-consistent decision-making, hazard-avoidance standards, and funding certainty for community-led delivery (Ministry for the Environment 2025a; 2025h).

4.8.3 Policy shortfall

Even if every existing and signalled action were fully delivered, a substantial portion of climate-related health risk for Māori would remain because binding drivers are structural and several sit beyond the reach of current policy instruments. Full delivery can reduce exposures through healthier housing, safer water, and strengthened primary and community care. It can lower sensitivity and raise adaptive capacity where Māori providers are stably funded, and emergency

roles are clear. Nevertheless, residual risk remains highest in rural and coastal districts where services are sparse and infrastructure brittle, and among groups who face layered exclusion (i.e. multiple forms of exclusion), disabled Māori, wāhine Māori, tamariki and rangatahi, kaumātua, and low-income renters (Ingham et al. 2022; Jones et al. 2024; Whitehead & Walker 2021).

Ecological and climatic changes will continue to drive health burdens even under best effort delivery. Heat–health relationships and extreme rainfall attribution indicate growing paediatric and cardio-respiratory pressures if there are no anticipatory housing, clinical, and planning responses (Harrington et al. 2023; Lai et al. 2024). Marine ecosystem shifts that diminish kaimoana abundance and quality can contribute to nutrition stress and cultural loss, with restoration requiring coordinated, long-term action beyond the health sector (Short et al. 2023; Bulmer et al. 2024). Community-led food systems and aquaculture initiatives offer promise for buffering shocks, but rely on enabling policy for land, water, and markets (Muncaster et al. 2024).

Structural determinants, such as poverty, insecure housing tenure, and institutional racism, shape who faces the most risk; health policy can ease some of this, but it cannot fix the underlying social and housing conditions on its own. Housing conditions in remote and low-income communities sustain respiratory and infectious disease risk; financial insecurity after major health events constrains recovery; and youth homelessness and precarious work magnify exposure and erode resilience for Māori communities (Su & Wu 2020; van Meijl 2020; Paul & Ratana 2022; Lisipeki et al. 2023). For wāhine Māori, intersections of climate impacts and health services can generate maladaptive outcomes if adaptation investments ignore gendered realities (Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Gaps in cardiovascular risk assessment and long-term condition management point to additional residual burden unless primary care models and outreach are re-designed with Māori (Daly et al. 2024; Wheeler et al. 2025).

Governance and knowledge settings are central to the policy shortfall. Where Te Tiriti is not put into operation (through shared authority, distinct Māori funding lines, and enforceable accountability) the residual risk falls disproportionately on Māori communities (Waitangi Tribunal 2023; Masters-Awatere, Young, & Graham 2022; Tapsell 2022; Johnson, Fisher & Parsons 2024; Johnson, Parsons & Fisher 2023). Without Indigenous data governance, digital exclusion and mistrust impede targeted preparedness and recovery (Walter et al. 2021; Kukutai 2024). Climate-related distress and mental health impacts are real but will remain under-addressed if responses focus narrowly on clinical services rather than the social and cultural determinants identified in the literature (Hayes et al. 2018; Lawrance et al. 2022; Apiti et al. 2023).

Current and proposed policy also leaves identifiable shortfalls. The disestablishment of the Māori Health Authority (under the Pae Ora [Disestablishment of Māori Health Authority] Amendment Act 2024) reduces a dedicated channel for Māori health commissioning unless offset by robust iwi-Māori partnership arrangements within Te Whatu Ora and clear accountabilities under the GPS and Te Pae Waenga (Health New Zealand/Te Whatu Ora 2025; Manatū Hauora 2024a). If updates to RMA national-direction and the Fast-track consenting regime accelerate projects in or near high-hazard zones without explicit Te Tiriti-consistent decision making and standards to protect health, exposure could shift toward already-marginalised communities. As these policy instruments are still evolving, this is a risk to watch rather than an observed outcome (Ministry for the Environment 2025c; 2025d; 2025h).

The national adaptation framework work programme remains in development. Until its funding settings, roles, and managed retreat pathways are settled, uncertainty will constrain proactive health planning in high-risk rohe (Ministry for the Environment, 2025a, 2025f). Finally, repeal of smokefree measures under the Smokefree Environments and Regulated Products Amendment Act

© New Zealand Institute for Bioeconomy Science Limited (2026)

2024 could increase long-term cardio-respiratory burdens unless smoking prevention and encouraging cessation are strengthened through other channels.

All the evidence suggests that closing the residual risk gap requires cross-sector measures, managed retreat that protects cultural connection, investment in tikanga-based infrastructure and papakāinga, Māori-led commissioning, and Indigenous data infrastructures, so that health policy is matched by governance and resource settings that enable Māori self-determined adaptation (Tait-Wall et al. 2022; Andersen 2024; Kukutai et al. 2024).

4.8.4 Overall assessment

Table 31 summarises policy readiness for this risk. Ratings are all for *Significant gaps.*

Policy coverage for climate-related health vulnerabilities affecting Māori is meaningful but incomplete. Multiple instruments provide direct protections (e.g., warm, dry, energy-safe homes; safe water) and service models that can mitigate cardio-metabolic and respiratory risks. Indirect land-use and infrastructure levers shape where hazards fall and how essential services endure, while adjusting settings (for data, workforce, commissioning, etc.) can support Māori-led responses. Nevertheless, putting health-related Te Tiriti commitments into operation remains uneven: many frameworks acknowledge partnership but translate this into consultation rather than shared authority, durable resourcing, and enforceable accountabilities.

The geographic and demographic reach is patchy, particularly in rural and coastal districts, where service footprints are thin and infrastructure is brittle. This is also the case for disabled Māori, wāhine Māori, tamariki/rangatahi, and kaumātua. Policy readiness to deliver is strongest in communities closest to Māori. Kaupapa Māori providers, marae, and iwi/hapū organisations have the legitimacy, relationships, and tikanga-grounded pathways to act quickly when heat, smoke, flood, or contamination events occur. Where formally empowered and resourced within command structures, delivery becomes faster and culturally safer. However, short funding cycles, informal roles, fragmented mandates, and workforce shortages result in uneven readiness. In addition, housing quality and water/wastewater vulnerabilities exacerbate health impacts; and data silos and digital exclusion hinder targeted preparedness.

Even with full implementation, significant gaps in policy readiness remain. Structural determinants and accelerating hazards will continue to drive burdens; health-sector tools alone cannot resolve the compounding pathways of mental-health, nutrition, and environmental distress. Closing the gap will require cross-sector action beyond health, managed retreat that protects cultural connection, investment in tikanga-based infrastructure and papakāinga, Māori-led commissioning, and Indigenous data infrastructures, so that policy intent translates into durable, Māori self-determined adaptation.

Looking ahead, the combination of the Government Policy Statement on Health 2024-2027 and the New Zealand Health Plan – Te Pae Waenga 2024-2027 can provide for more precise planning and a basis for better monitoring. The proposed Mental Health Bill and Healthy Futures (Pae Ora) Amendment Bill signal that further changes are still possible. Finally, climate/adaptation and resource-management reforms currently under way remain key external drivers of health risk distribution and system readiness (Health New Zealand/Te Whatu Ora 2025; Manatū Hauora 2024b, 2025; Ministry for the Environment 2024; 2025a; 2025h).

Overall readiness: *Significant gaps*. Readily available policy exists, and Māori-led local capability is strong. Uneven implementation of Te Tiriti principles, fragmented mandates, short funding cycles, workforce gaps, and weak cross-sector integration curtail system readiness. Recent plans clarify

priorities (e.g., GPS–Te Pae Waenga) but are offset by the loss of a dedicated Māori commissioning entity, equity-tool withdrawal, and unsettled adaptation/resource management settings. Without Te Tiriti-consistent decision-making and durable funding/data infrastructures, readiness remains constrained.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Table 31: Policy readiness assessment for increased health vulnerabilities

Dimension	Rationale	Score
Policy coverage	Policy settings span health reforms, NAF, emergency management, housing/water regulation, environmental management, and social protection, with direct standards (e.g., for warm, dry homes; safe water), primary/community care models, indirect land-use/infrastructure levers, and enabling data/workforce. Putting Te Tiriti principles into operation is uneven, and coverage is patchy for rural/coastal and priority groups. Since 2024, The GPS on Health 2024–2027 (GPS) has underpinned the New Zealand Health Plan – Te Pae Waenga 2024–2027 (Te Pae Waenga). The Pae Ora (Disestablishment of Māori Health Authority) Amendment Act 2024 alters commissioning, The Smokefree 2024 rollbacks, and an adaptation framework is being developed. Fast-track/RMA updates may shift exposure if they progress without Te Tiriti-consistent decision-making.	Significant gaps
Readiness to implement/deliver	Delivery is strongest via kaupapa Māori providers, marae and iwi/hapū when these sit in command structures. Many Māori health agencies rely on short-term funding, informal roles, and vertical accountabilities; rural/coastal workforce shortages persist. Data silos and digital exclusion hinder targeting. GPS–Te Pae Waenga can stabilise planning if commissioning is certain; Equity Adjustor removal from surgery wait lists weakens prioritisation; The proposed Mental Health Bill (introduced 2024) and Healthy Futures (Pae Ora) Amendment Bill (introduced 2025) have yet to progress through the House, so near-term capacity gains from anything they contain are uncertain.	Significant gaps
Policy shortfall	Even with full delivery, structural determinants and intensifying hazards sustain residual risk; rural/coastal and high-risk groups face ongoing heat, smoke, flood, and contamination exposure. Health levers alone cannot address compounding mental health and nutrition distress pathways. Durable policy will need cross-sector measures (e.g., tikanga-based infrastructure, papakāinga, Māori-led commissioning, Indigenous data infrastructures). Disestablishing the Māori Health Authority (MHA) has removed dedicated commissioning for Māori health agencies. Smokefree (NZ) 2024 rollbacks may increase cardio-respiratory burden, and unresolved adaptation settings keep exposure elevated.	Major
Overall readiness	Readily available policy exists, and Māori-led local capability is strong. Uneven implementation of Te Tiriti principles, fragmented mandates, short funding cycles, workforce gaps, and weak cross-sector integration curtail system readiness. Recent plans clarify priorities (e.g., GPS–Te Pae Waenga) but are offset by the loss of a dedicated Māori commissioning entity, equity-tool withdrawal, and unsettled adaptation/resource management settings. Without Te Tiriti-consistent decision-making and durable funding/data infrastructures, readiness remains constrained.	Significant gaps

Table note: Shading indicates severity. **Green** = No significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Minor policy shortfall. **Yellow** = Moderate gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Moderate policy shortfall. **Orange** = Significant gaps (policy coverage/ readiness to implement/deliver/ overall readiness) or Major policy shortfall. **Red** = Insufficient (policy coverage/ readiness to implement/deliver/ overall readiness) or Extreme policy shortfall.

© New Zealand Institute for Bioeconomy Science Limited (2026)

5 Part 3: Summary of policy readiness

5.1 Loss of access to taonga species

Policy coverage is evident across specific programmes and research projects (e.g., Te Whaitua Te Whanganui-a-Tara implementation programme; kina-to-kelp work; establishing Taura Kuku and Kohunga Kūtai projects), indirect levers (catchment/forestry controls; pending RMA direction), and enabling foundations (CCVAs, cultural indicators, MMFS, Māori data sovereignty). Given patchy/pilot-heavy uptake, unclear mandates and durable funding, variable integration of mātauranga Māori, and high residual risk from climate and legacy pressures, the overall readiness score is *Insufficient* (Table 24).

The conditions that would lift readiness include Te Tiriti-consistent co-decision-making, tightened sediment/forestry rules, and sustained investment in Māori-led programmes and data infrastructure.

5.2 Damage to Māori infrastructure

Aotearoa's current approach to Māori infrastructure lacks enforceable protections, with most policies being proposed or discretionary. While initiatives like Te Puni Kōkiri's hazard resource and marae-resilience programmes show potential, the implementation is hindered by inadequate funding, technical standards, and inconsistent council capabilities. Structural challenges, including legacy issues and cultural impacts, mean that engineering solutions alone are not enough. Without strong Te Tiriti commitments and tikanga-centred standards, risks will remain disproportionately on Māori communities. The overall readiness score is *Insufficient* (Table 24).

Key priorities for lifting readiness include defining roles, enhancing national direction, securing funding for the national adaptation framework, and scaling successful Māori models into mandated practices.

5.3 Economic losses in primary industries

Policy coverage for climate adaptation and mitigation is broadening, but remains broadly enabling, with Māori-specific loss reduction depending on generic pathways and pilots. Readiness is strongest where Māori organisations lead but weakens at multi-agency interfaces because of regional variability and unsettled funding. Key policy shortfalls include ecological regime shifts and financial constraints on Māori lands (whenua Māori), resulting in high residual losses. The overall readiness score is *Significant gaps* (Table 24).

To improve readiness, there should be binding co-decision-making aligned with Te Tiriti-consistent rules on sediment management and managing the cumulative effects of sedimentation. Also, standardised consent templates, and sustained investment in Māori-led initiatives.

5.4 Disruptions to tikanga and hapū/iwi identity

Policy coverage for Māori interests is inconsistent and lacks mandated Te Tiriti-based governance and tikanga planning at scale. Key frameworks, such as a Climate Adaptation Act, are underdeveloped, and RMA changes are uncertain, with fast-tracking projects exposing important cultural sites without proper safeguards. While Māori-led initiatives show strong readiness, the state system remains fragmented with unclear roles, inconsistent funding, and varying regional practices. This results in significant risks to tikanga, whakapapa, and community identity, indicating

© New Zealand Institute for Bioeconomy Science Limited (2026)

the current system is not yet reliable or consistent with Te Tiriti to protect Māori interests nationwide effectively. The overall readiness score is *Insufficient* (Table 24).

To improve readiness, a reliable or Te Tiriti-consistent pathway to safeguard tikanga and hapū/iwi identity nationwide is required.

5.5 Loss of Indigenous knowledge systems

Current policy acknowledges mātauranga Māori but does not consistently integrate it into planning, investment, or approvals. While some local councils and Māori-led programmes show progress, challenges include uneven uptake, inconsistent resources, and unclear legal mandates. The Fast-track Approvals Act 2024 and RMA updates have the potential to enhance or diminish protections for Māori practices. Despite existing tools, ecological changes, and knowledge loss, there is a significant a shortfall in readiness. The overall readiness score is *Insufficient* (Table 24).

To close this gap, there is a need for clearly defined statutory roles for Māori, a Māori Resilience Fund (See Sections 4.5 and 4.6), and investment in knowledge initiatives.

5.6 Legal exclusion and governance failures

Current policies recognise Māori interests but lack genuine power to make co-decisions. While Māori-led initiatives operate effectively, they generally rely on voluntary efforts and short-term funding. Proposed RMA reforms may improve resource management but require binding mandates and Māori-governed data platforms. The overall readiness score is *Insufficient* (Table 24).

To enhance readiness, policies should include co-governance provisions, devolve powers to Māori authorities, and incorporate mātauranga Māori in planning. Without these changes, advisory roles of Māori will persist, leading to ongoing procedural exclusion and increased risks for Māori communities, particularly in urban areas and regions facing environmental challenges.

5.7 Increased health vulnerabilities

Policy coverage for climate-related health vulnerabilities affecting Māori is material but inconsistent. While some protections exist, such as safe housing and water, making Te Tiriti obligations operational remains uneven, favouring consultation over shared authority. Vulnerabilities are particularly pronounced for rural and coastal communities, disabled Māori, and kaumātua. Kaupapa Māori providers are well-placed to respond to climate events, but face challenges like short funding cycles and workforce shortages. The overall readiness score is *Significant gaps* (Table 24).

Even with full implementation of some favourable policies, enhancing readiness will need cross-sector action, dedicated resourcing for Māori health commissioning, and investment in Indigenous data infrastructure.

© New Zealand Institute for Bioeconomy Science Limited (2026)

6 Acknowledgements

E mihi ana ki ngā mātanga o Ngā Pae o te Māramatanga. We extend our deep appreciation to Professor John Reid, Professor Merata Kawharu, Dr Amohia Boulton, and Professor Ocean Mercier for their generous support, insightful guidance, and expertise, which have strengthened both the quality and integrity of this report. Their contribution reflects a spirit of manaakitanga and collective commitment to advancing Māori research excellence.

Declaration of the use of generative AI/AI-assisted technologies

As described in our Methods (Section 2), we used ChatGPT 5 (OpenAI 2025) as a language support tool to increase analytical efficiency in preparing this report.

ChatGPT was used to:

- generate draft summaries of long-form documents
- identify content relevant to NCCRA risk components
- suggest supplementary citations to support or expand existing risk statements
- ensure narrative consistency across sections
- moderate tone and phrasing to reflect a cautious and evidence-based approach.

After using this tool/service, the content was reviewed and edited as needed by the authors.

See Section 2.3 in our Methods for further information.

© New Zealand Institute for Bioeconomy Science Limited (2026)

7 References

Aitken J, Shadbolt M, Doherty J, Mark-Shadbolt M, Marzano M, Ataria J 2021. Empowering the indigenous voice in a graphical representation of Aotearoa's biocultural heritage (flora and fauna). Pacific Conservation Biology 27(4): 481–492. https://doi.org/10.1071/PC20027

Andersen E 2024. Small homes are our past and future: hapū experiences and aspirations. Report for FAAB Small Homes. Building Better Homes, Towns and Cities National Science Challenge. https://www.buildingbetter.nz/wp-content/uploads/2024/06/FAAB-Report-Ngati-Kapu-Final-10-June.pdf (accessed 1 May 2025)

Apiti A, Tassell-Matamua N, Lindsay N, Dell K, Pomare P, Erueti B, Masters-Awatere B, Te Rangi M 2023. Indigenous Māori of Aotearoa (New Zealand): environmental identity, rather than Māori identity per se, has the greatest influence on environmental distress. Ecopsychology 15(2): 119–129. https://doi.org/10.1089/eco.2022.0053

Awatere S, King DN, Reid J, Williams L, Masters-Awatere B, Harris P, Tassell-Matamua N, Jones R, Eastwood K, Pirker J, Jackson A-M 2021. He huringa āhuarangi, he huringa ao: a changing climate, a changing world. Manaaki Whenua – Landcare Research Contract Report LC3948. https://www.landcareresearch.co.nz/assets/researchpubs/He-huringa-ahuarangi-he-huringa-ao-a-changing-climate-a-changing-world.pdf (accessed 30 April 2025)

Ayala MB 2023. Walking, sensing, knowing: an ethnography on foot around forest biosecurity interventions in Te-Ika-ā-Māui. Knowledge Cultures 11(1): 260–281. https://doi.org/10.22381/kc111202313

Bailey K. 2022. Reflections on kaumātua, pakeke and seniors' housing. In: Saville-Smith K, Cram F, James B, Robinson A eds. *Affordable housing for generations*. Wellington: Building Better Homes, Towns and Cities. Pp. 1–48. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Bailey_nov2022_reflections_on_kaumatua_and_seniors_housing.pdf (accessed 30 April 2025).

Bailey-Winiata AP, Gallop SL, White I, Wotherspoon L, Fa'aui T, Dickson M, Ellis J 2024. Looking backwards to move forwards: insights for climate change adaptation from historical Māori relocation due to natural hazards in Aotearoa New Zealand. Regional Environmental Change 24(2): 80. https://doi.org/10.1007/s10113-024-02240-5

Bargh M, Tapsell E 2021. For a tika transition. Policy Quarterly 17(3): 13–22. https://doi.org/10.26686/pq.v17i3.7126

Barnes LA, Eng A, Corbin M, Denison HJ, t'Mannetje A, Haslett S, Douwes J 2022. A longitudinal linkage study of occupation and ischaemic heart disease in the general and Māori populations of New Zealand. PLoS One 17(1): e0262636. https://doi.org/10.1371/journal.pone.0262636

Berghan J 2021. Kaupapakāinga: the potential for Māori cohousing. Building Better Homes, Towns and Cities. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Berghan_2021_kaupapakainga_potential_for_maori_cohousing.pdf (accessed 30 April 2025).

Bissett M 2025. Revitalising native flora: the role of TTW in seed banking. Te Tira Whakamātaki. https://www.ttw.nz/revitilizingnativeflorastory (accessed 30 April 2025)

Blake D, Adams-Hutcheson G, Gibbs L, Quinn P 2022. Post disaster residential mobility: considerations for Aotearoa New Zealand. Australasian Journal of Disaster and Trauma Studies 26(3): 107–116. https://openaccess.wgtn.ac.nz/articles/journal_contribution/Post-

© New Zealand Institute for Bioeconomy Science Limited (2026)

disaster_residential_mobility_Considerations_for_Aotearoa_New_Zealand_and_Australia/21769154/1/files/38630564.pdf (accessed 30 April 2025)

Blake D, Rijnink A, Lyons A, Aspin C 2024. Losing everything: experiences of a flood for people who inject drugs in Aotearoa New Zealand. International Journal of Disaster Risk Reduction 106: 104440. https://doi.org/10.1016/j.ijdrr.2024.104440

Boulton A, Devine T, McMenamin K, Walsh Tapiata W 2022. Te Ranga Tupua: an Iwi (tribal) response to COVID-19 in Aotearoa New Zealand. International Journal of Indigenous Health 17(1): 3-15. https://jps.library.utoronto.ca/index.php/ijih/article/view/36718/29675 (accessed 30 April 2025)

Buckley HL, Hall D, Jarvis RM, Smith V, Walker LA, Silby J, Hinchliffe G, Stanley MC, Sweeney AP, Case BS 2023. Using long-term experimental restoration of agroecosystems in Aotearoa New Zealand to improve implementation of nature-based solutions for climate change mitigation. Frontiers in Forests and Global Change 5: 950041. https://doi.org/10.3389/ffgc.2022.950041

Bulmer R, Pilditch C, Stephenson F, Shears N, Flowers G 2024. Assessing potential recovery solutions to shift from kina barrens to kelp forests. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Kina-barrens/Kina-barrens-to-kelp-forests.pdf (accessed 30 April 2025)

Bush International Consulting 2024. Hawke's Bay Civil Defence Emergency Management Group response to Cyclone Gabrielle: independent review final report. Hawke's Bay Civil Defence Emergency Management Group. https://www.hbemergency.govt.nz/assets/Uploads/HBCDEM-Response-to-Cyclone-Gabrielle-Final-Report.pdf (accessed 30 April 2025)

Cassim S, Keelan TJ 2023. A review of localised Māori community responses to Covid-19 lockdowns in Aotearoa New Zealand. AlterNative: An International Journal of Indigenous Peoples 19(1): 42–50. https://doi.org/10.1177/11771801221124428

Cleghorn C, Nghiem N, Ni Mhurchu C 2022. Assessing the health and environmental benefits of a New Zealand diet optimised for health and climate protection. Sustainability 14(21): 13900. https://doi.org/10.3390/su142113900

Clinton A, Dixon B, Morrissey T 2022. Climate action and global psychology. Wellington, New Zealand Psychological Society. https://www.psychology.org.nz/download_file/view/1840/414 (accessed 30 April 2025)

Cram F 2021. Mahi aroha: Māori work in times of trouble and disaster to express a love for the people. Kotuitui: New Zealand Journal of Social Sciences Online 16(2): 356–370. https://doi.org/10.1080/1177083X.2021.1879181

Daly BM, Wu Z, Nirantharakumar K, Chepulis L, Rowan JA, Scragg RK 2024. Increased risk of cardiovascular and renal disease, and diabetes for all women diagnosed with gestational diabetes mellitus in New Zealand—a national retrospective cohort study. Journal of Diabetes 16(4): e13535. https://doi.org/10.1111/1753-0407.13535

Deep South Challenge 2024. Ki te whare tū tonu, ki te whare manawaroa: towards a climate resilient meeting house. https://deepsouthchallenge.co.nz/ki-te-whare-tu-tonu-ki-te-whare-manawaroa-towards-a-climate-resilient-meeting-house/ (accessed 30 April 2025)

Department of Internal Affairs 2024. Report of the Government Inquiry into the response to the North Island severe weather events. Wellington, Department of Internal Affairs.

https://www.dia.govt.nz/Government-Inquiry-into-the-Response-to-the-North-Island-Severe-Weather-Events (accessed 31 October 2025)

Egan E, Woolley J-M, Williams E 2020. Climate change vulnerability assessment of selected taonga species: technical report. NIWA Client Report 2020073CH. Wellington, National Institute of Water & Atmospheric Research (NIWA). https://waimaori.maori.nz/wp-content/uploads/2020/09/2020073CH_Report_FINAL_15April-Technical-Report.pdf (accessed 30 April 2025)

E Oho! Awakening Aotearoa 2023. Submission to the Environment Committee: inquiry into community-led retreat and climate adaptation. https://resiliencechallenge.nz/wp-content/uploads/E-Oho-Awakening-Aotearoa-Submission-to-the-Environment-Committee-Inquiry-into-Community-led-Retreat-and-Climate-Adaptation-01-Nov-2023.pdf (accessed 30 April 2025)

Envirostrat Limited 2024. Nature risks and opportunities in Hawke's Bay: a place-based approach to understanding nature risks and business readiness for nature disclosure. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/tools-and-resources/nature-risks-and-opportunities/ (accessed 30 April 2025)

Erueti B, Tassell-Matamua N, Pomare P, Masters-Awatere B, Dell K, Te Rangi M, Lindsay N 2023. 'Pūrākau o te Ngahere': indigenous Māori interpretations, expressions and connection to taonga species and biosecurity issues. Knowledge Cultures 11(1): 34–54. https://doi.org/10.22381/kc11120233

Expert Working Group on Managed Retreat 2023. Report of the Expert Working Group on Managed Retreat: a proposed system for Te Hekenga Rauora/Planned Relocation. Wellington, Expert Working Group on Managed Retreat. https://environment.govt.nz/assets/publications/climate-change/Report-of-the-Expert-Working-Group-on-Managed-Retreat-updated-08-24.pdf (accessed 30 April 2025)

Graham R, Masters-Awatere B, Cowan C, Stevens A, Wilkinson R. 2021. COVID-19 and blind spaces: responding to digital (in)accessibility and social isolation during lockdown for blind, deafblind, low vision and vision impaired persons in Aotearoa New Zealand. In: Doucet B, van Melik R, Filion P eds. *Global reflections on COVID-19 and urban inequalities. Volume 1: Community and Society*. Bristol: Bristol University Press. Pp. 235–244. https://doi.org/10.51952/9781529218893.ch021 (accessed 30 April 2025)

Hall M, Bargh M, Tēmara T, Ross M, Skerrett M, Shedlock K, McRae H, Thomson R, Potangaroa R, Mulligan R, North L 2024. He Pā Mataora—learning to live with the Living Pā: final report. Report to the National Science Challenge Deep South. Te Herenga Waka—Victoria University of Wellington. https://deepsouthchallenge.co.nz/wp-content/uploads/2024/09/He-Pa-Mataora-Learning-to-live-with-the-Living-Pa-Final-Report.pdf (accessed 30 April 2025)

Harrington LJ, Dean SM, Awatere S, Rosier S, Queen L, Gibson PB, Otto FE 2023. The role of climate change in extreme rainfall associated with Cyclone Gabrielle over Aotearoa New Zealand's East Coast. World Weather Attribution. https://doi.org/10.25561/102624

Hayden M, Lundquist C, Kainamu A 2023. Hapū and iwi perceptions of cumulative effects: towards supporting kaitiakitanga. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Hapu-and-iwi-perceptions-of-cumulative-effects/Hapu-and-iwi-perceptions-of-CE.pdf (accessed 30 April 2025)

Hayes K, Blashki G, Wiseman J, Burke, S, Reifels, L 2018. Climate change and mental health: risks, impacts and priority actions. International Journal of Mental Health Systems 12: 28. https://doi.org/10.1186/s13033-018-0210-6

© New Zealand Institute for Bioeconomy Science Limited (2026)

Heaps A 2023. The upstream social determinants of asthma in New Zealand: a public health essay. New Zealand Medical Student Journal: Te hautaka o ngā akonga rongoā 35: 15–18. https://doi.org/10.57129/001c.73279

Health New Zealand / Te Whatu Ora 2025. New Zealand Health Plan | Te Pae Waenga 2024–2027. https://www.beehive.govt.nz/release/patient-focused-new-zealand-health-plan-tabled (accessed 22 September 2025).

Hikuroa D, Le Heron R, Le Heron E. 2021. Pre-conditions for making (desired) markets in the spirit of Ki Uta Ki Tai–Mountains to the Sea: re-commoning and economic-environment transitionings. In: Prince R, Henry M, Morris C, Gallagher A, FitzHerbert S eds. *Markets in their Place: Context, Culture, Finance*. Abingdon: Routledge. Pp. 82–101. https://doi.org/10.4324/9780429296260-5 (accessed 30 April 2025)

Hogarth K, Rapata-Hanning M. 2023. Māori health in Aotearoa New Zealand. In: Craft J, Gordon C eds. *Understanding Pathophysiology: Australia and New Zealand Edition*. 4th ed. Sydney: Elsevier Australia. Pp. 1243–1260. https://www.researchgate.net/profile/Mereana-Rapata-Hanning-2/publication/329222978_Maori-health-in-Aotearoa-New-Zealand/links/6061b6c8a6fdccbfea14771c/Maori-health-in-Aotearoa-New-Zealand.pdf (accessed 30 April 2025)

Houkamau CA, Dell KM, Newth J, Mika J, Sibley C, Keelan T, Dunn T 2021. The well-being of Māori pre and post Covid-19 lockdown in Aotearoa/New Zealand. Auckland, University of Auckland. http://hdl.handle.net/10179/16453 (accessed 30 April 2025)

Howarth L, Major R 2023. Key environmental considerations for seaweed aquaculture in Aotearoa New Zealand. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Key-environmental-considerations-for-seaweed-aquaculture/Key-environmental-considerations-for-seaweed-aquaculture-in-Aotearoa-New-Zealand.pdf (accessed 30 April 2025)

Hughes J, Cowper-Heays K, Olesson E, Bell R, Stroombergen A 2021. Impacts and implications of climate change on wastewater systems: a New Zealand perspective. Climate Risk Management 31: 100262. https://doi.org/10.1016/j.crm.2020.100262

Hutchings J, Smith J, Taura Y, Harmsworth G, Awatere S 2020. Storying kaitiakitanga: exploring Kaupapa Māori land and water food stories. MAI Journal 9(3): 183–196. https://doi.org/10.20507/MAIJournal.2020.9.3.1

Ingham TR, Jones B, Perry M, King PT, Baker G, Hickey H, Pouwhare, R, Nikora LW 2022. The multidimensional impacts of inequities for Tāngata Whaikaha Māori (Indigenous Māori with lived experience of disability) in Aotearoa, New Zealand. International Journal of Environmental Research and Public Health 19(20): 13558. https://www.mdpi.com/1660-4601/19/20/13558

Ingham TR, Jones B, Perry M, von Randow M, Milne B, King PT, Nikora, L, Sporle, A, Te Ao Mārama Study Group 2023. Measuring Māori health, well-being, and disability in Aotearoa using a web-based survey methodology. International Journal of Environmental Research and Public Health 20(18): 6797. https://www.mdpi.com/1660-4601/20/18/6797

Johnson D, Blackett P 2024. Assessing social vulnerability to climate change at the coast: a report for the Resilience to Nature's Challenges National Science Challenge. https://resiliencechallenge.nz/wp-content/uploads/Social-Vulnerability-Report-Full-Length-2024.pdf (accessed 30 April 2025)

© New Zealand Institute for Bioeconomy Science Limited (2026)

Johnson D, Fisher K, Parsons M 2022. Diversifying Indigenous vulnerability and adaptation: an intersectional reading of Māori women's experiences of health, well-being, and climate change. Sustainability 14(9): 5452. https://doi.org/10.3390/su14095452

Johnson D, Fisher K, Parsons M 2024. Resistance, resurgence, and well-being: climate change loss and damages from the perspective of Māori women. EPE: Nature and Space 7(3): 1318–1364. https://doi.org/10.1177/25148486231217891

Johnson D, Parsons M, Fisher K 2023. Adaptation at whose expense? Explicating the maladaptive potential of water storage and climate-resilient growth for Māori women in northern Aotearoa. Global Environmental Change 82: 102733. https://doi.org/10.1016/j.gloenvcha.2023.102733

Jones B, King PT, Baker G, Nikora LW, Hickey H, Perry M, Pouwhare, R, Ingham TR 2024. Karanga rua, karanga maha: Māori with lived experience of disability self-determining their own identities. Kōtuitui: New Zealand Journal of Social Sciences Online 19(1): 45–64. https://www.tandfonline.com/doi/abs/10.1080/1177083X.2023.2224422

Kainamu A, Rolleston-Gabel T 2023. A review of te ao Māori perspectives of marine scales and where these are impeded by contemporary management. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/te-ao-Maori-perspectives-of-marine-scales/Te-ao-Maori-perspectives-of-marine-scales.pdf (accessed 30 April 2025)

Kainamu-Murchie AA, Marsden ID, Tau RT, Gaw S, Pirker J 2018. Indigenous and local peoples' values of estuarine shellfisheries: moving towards holistic-based catchment management. New Zealand Journal of Marine and Freshwater Research 52(4): 526–541. https://doi.org/10.1080/00288330.2018.1523200

Kaiwai H, Allport T 2023. Māori with disabilities (part two). Report commissioned by the Waitangi Tribunal for the Health Services and Outcomes Inquiry (Wai 2575, 2019). https://www.abuseincare.org.nz/assets/Evidence-library/Interim-Report-2023-Stolen-Lives-Marked-Souls/Kaiwai-H-Allport-T-Maori-with-disabilities-part-two-Report-commissioned-by-the-Waitangi-Tribunal-for-the-Health-Services-and-Outcomes-Inquiry-Wai-2575-2019.pdf (accessed 30 April 2025)

Kawharu M (2023). Ko ngā kōrero o ngā mana whenua. Interim research report, Innovations for Climate Adaptation, Deep South National Science Challenge. Centre for Sustainability, University of Otago. https://deepsouthchallenge.co.nz/resource/ko-nga-korero-o-nga-mana-whenua/ (accessed 30 April 2025)

Kenney C, Phibbs S. 2021. Indigenous peoples and climate change: situating culture, identity, and place in climate change risk mitigation and resilience. In: Leal Filho W, Luetz J, Ayal D eds. *Handbook of Climate Change Management*. Cham: Springer International Publishing. Pp. 2201–2227. https://doi.org/10.1007/978-3-030-57281-5_113

King P, Cormack D, McLeod M, Harris R, Gurney J 2020. COVID-19 and Māori health – when equity is more than a word. Public Health Expert Briefing. https://www.phcc.org.nz/briefing/covid-19-and-maori-health-when-equity-more-word (accessed 30 April 2025)

King-Hunt ARK 2023. Novel biotechnological controls for social wasp eradication: exploring religious and spiritual Māori perceptions using a Q-Method and kaupapa Māori methodology. Unpublished Master's thesis, Victoria University of Wellington, Wellington.

Kingi T 2008. Māori landownership and land management in New Zealand. Making land work 2: 129–151. https://www.dfat.gov.au/sites/default/files/MLW_VolumeTwo_CaseStudy_7.pdf

© New Zealand Institute for Bioeconomy Science Limited (2026)

Kingi T, Wakelin S, Journeaux P, West G 2023. Collective land tenure systems and greenhouse gas mitigation among Māori farmers in Aotearoa New Zealand. In: D'Arcy P, Da-Wei Kuan DD eds. *Islands of hope: Indigenous resource management in a changing Pacific*. Canberra, ANU Press. Pp. 245–262. https://doi.org/10.22459/IH.2023.13

Kukutai T 2024. How Indigenous communities in New Zealand are protecting their data. Science 384(6691): eado9298. https://www.science.org/doi/abs/10.1126/science.ado9298

Kukutai T, McIntosh T, Boulton A, Durie M, Foster M, Hutchings J et al 2024. Te Pūtahitanga: a Tiriti-led science-policy approach for Aotearoa New Zealand. AgResearch Report. https://doi.org/10.57935/AGR.26001496.v1

Lai H, Lee JE, Harrington LJ, Ahuriri-Driscoll A, Newport C, Bolton A, Salter C, Morton S, Woodward A, Hales S 2024. Daily temperatures and child hospital admissions in Aotearoa New Zealand: case time series analysis. International Journal of Environmental Research and Public Health 21(9): 1236. https://www.mdpi.com/1660-4601/21/9/1236

Lambert M, Mark-Shadbolt M 2021. Indigenous knowledges of forest and biodiversity management: how the *watchfulness* of Māori complements and contributes to disaster risk reduction. *AlterNative* 17(3): 368-377 https://doi.org/10.1177/11771801211038760

Lawrance EL, Thompson R, Newberry Le Vay J, Page L, Jennings N 2022. The impact of climate change on mental health and emotional well-being: a narrative review of current evidence, and its implications. International Review of Psychiatry 34(5): 443–498. https://doi.org/10.1080/09540261.2022.2128725

Lisipeki S, Masters-Awatere B, Hodgetts D, Liew TV 2023. Reciprocal relations between cardiovascular disease, employment, financial insecurity, and post cardiac event recovery among Māori men: a case series. Journal of Medical Case Reports 17: 468. https://doi.org/10.1186/s13256-023-04202-7

Lohrer D, Alder A, Bellingham P, Berthelsen A, Biessy L, Biggs E, Booker D, Burge O, Cavanagh J, Clement D, Coulson G, D'Archino R, Davies-Colley R, Drewry J, Dudley B, Etherington T, Gall M, Greenwood M, Harcourt N, Herangi N, Hughes A, Kainamu A, Lam-Gordillo O, Lundquist C, Matheson F, McCarthy J, McNally S, Morrison M, Peltzer D, Phillips C, Pinkerton M, Plew D, Pronger J, Rajanayaka C, Somervell E, Stott R, Swales A, Stewart-Sinclair P, Tait L, Tanner C, Thompson-Morrison H, Tremblay L, Walker S, Williams E, Wilton E, Wood D, Zammit C 2024. Information stocktakes of fifty-five environmental attributes across air, soil, terrestrial, freshwater, estuaries and coastal waters domains. NIWA Report 2024216HN. Prepared for the Ministry for the Environment. Wellington, National Institute of Water and Atmospheric Research (NIWA). https://environment.govt.nz/publications/information-stocktakes-of-fifty-five-environmental-attributes (accessed 30 April 2025)

Lück M, Fountain J, Rosin C 2024. Developing marine and coastal ecotourism: recommendations for tourism operators and policy makers. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/our-research/growing-marine-ecotourism/ (accessed 30 April 2025)

Lundquist CJ, Ramsay D, Bell R, Swales A, Kerr S 2011. Predicted impacts of climate change on New Zealand's biodiversity. Pacific Conservation Biology 17(3): 179–191. https://doi.org/10.1071/PC110179

Macpherson E, Jorgensen E, Paul A, Rennie H, Fisher K, Talbot-Jones J, Hewitt J, Allison A, Banwell J, Parkinson A 2023. Designing law and policy for the health and resilience of marine and coastal ecosystems—lessons from (and for) Aotearoa New Zealand. Ocean

Development & International Law 54(2): 200–252. https://doi.org/10.1080/00908320.2023.2224116

Mahuta R, van Schravendijk-Goodman C eds, with Swamp Frog Environmental & Tree Consultants Ltd 2024. Eating with my tuupuna: practices, kai and hākari of Poukai, Waikato. https://deepsouthchallenge.co.nz/wp-content/uploads/2024/11/Eating-with-my-Tuupuna_Full-Handbook.pdf (accessed 30 April 2025)

Manatū Hauora – Ministry of Health 2024a. Government policy statement on health 2024–2027. https://www.health.govt.nz/system/files/2024-06/government-policy-statement-on-health-2024-2027-v4.pdf (accessed 22 September 2025).

Manatū Hauora – Ministry of Health 2024b. Repealing and replacing the Mental Health Act. https://www.health.govt.nz/regulation-legislation/mental-health-and-addiction/repealing-and-replacing-the-mental-health-act (accessed 22 September 2025).

Manatū Hauora – Ministry of Health 2025. Healthy futures (Pae Ora) amendment bill. https://www.health.govt.nz/about-us/new-zealands-health-system/overview-and-statutory-framework/pae-ora-healthy-futures-act/healthy-futures-pae-ora-amendment-bill (accessed 22 September 2025).

Mannakkara S, Elkhidir A, Matiu L. 2023. The journey towards understanding and valuing Indigenous knowledge for climate change adaptation in Northland, Aotearoa–New Zealand. In: Shaw R, Dubeux D, Ouma Y eds. *Indigenous Knowledge and Disaster Risk Reduction*. Cham: Springer. Pp. 387–416. https://doi.org/10.1007/978-3-031-26143-5_17

Marshall IJ, Wallace BC 2019. Toward systematic review automation: a practical guide to using machine learning tools in research synthesis. Systematic Reviews 8: 163. https://doi.org/10.1186/s13643-019-1074-9

Masters-Awatere B 2021. Me tiro whakamuri, kia anga whakamua: walking backwards into the future. Psychology Aotearoa 13(2): 73–79 https://www.psychology.org.nz/application/files/1716/4262/9255/Bridgette.pdf

Masters-Awatere B, Graham R, Cowan C 2024. Working together to support self-determination for tāngata kāpō (blind and low vision) Māori: an exemplar. International Journal of Environmental Research and Public Health 21(3): 343. https://doi.org/10.3390/ijerph21030343

Masters-Awatere B, Young P, Graham R 2022. State agencies and researchers engaging with Indigenous communities on climate change adaptation planning: a systematic review. MAI Journal 11(1): 3–17. https://www.journal.mai.ac.nz/journal/mai-journal-2022-volume-11-issue-1

Masters-Awatere B, Young T, Howard D, Powell E, Ranginui Charlton A, Graham R, Dixon R 2022. Haumanu hauora: strengthening health institution responsiveness to climate change. Māori and Psychology Research Unit, University of Waikato. https://deepsouthchallenge.co.nz/wp-content/uploads/2023/05/Haumanu-Hauora-DSCFINAL-Report-22072022.pdf (accessed 30 April 2025)

Mayall-Nahi M, Williams E, May K, Kainamu A, Ratana K 2021. Navigating risk within iwi/hapū environmental decision-making: potential pathways based on the published literature. NIWA Client Report 2021380WN. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Navigating-risk-within-iwi/hapu-environmental-decision-making-Potential-pathways-based-on-the-published-literature/Navigating-risk-within-iwi-hapu.pdf (accessed 30 April 2025)

© New Zealand Institute for Bioeconomy Science Limited (2026)

McLellan G, Mika J 2024. Iwi collective partnership case study: implementing tikanga Māori in the business and activity of fishing. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/tools-and-resources/implementing-tikanga-m%C4%81ori-in-the-business-and-activity-of-fishing/ (accessed 30 April 2025)

McMeeking S, Savage C 2020. Māori responses to Covid-19. Policy Quarterly 16(3). https://doi.org/10.26686/pq.v16i3.6553

McMillan A, Dymond J, Jolly B, Shepherd J, Sutherland A 2023. Rapid assessment of land damage – Cyclone Gabrielle. Manaaki Whenua – Landcare Research Contract Report LC4292. https://environment.govt.nz/assets/Rapid-assessment-of-land-damage-Cyclone-Gabrielle-Manaaki-Whenua-Landcare-Research-report.pdf (accessed 30 May 2025)

Mead ATP, Smith V, Te Puawai Wilson-Leahy, Ogilvie S, Watene E, Potter H, Shadbolt MR 2022. When the Crown controls mātauranga: a report on a survey of Crown policies, programmes, legislation, funding, and impact assessment relating to mātauranga Māori. New Zealand's Biological Heritage, National Science Challenge Ngā Koiora Tuku Iho. https://bioheritage.nz/wp-content/uploads/2019/04/When-the-Crown-controls-matauranga_Full.pdf (accessed 30 April 2025)

Mika J, MacDonald T 2024. Whakatautika: generating balance in the business and activity of fishing at Moana New Zealand. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/tools-and-resources/whakatautika/ (accessed 30 April 2025)

Ministerial Inquiry into Land Use 2023. Outrage to optimism: ministerial inquiry into land uses associated with the mobilisation of woody debris (including forestry slash) and sediment in Tairāwhiti/Gisborne District and Wairoa District. Wellington, Department of the Prime Minister and Cabinet. https://environment.govt.nz/assets/Outrage-to-optimism-superseded.pdf (accessed 30 April 2025)

Ministry for the Environment 2024. The Government's climate strategy. https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/about-new-zealands-climate-change-programme/governments-climate-strategy/ (accessed 22 September 2025).

Ministry for the Environment 2025a. Adaptation framework. https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/adapting-to-climate-change/adaptation-framework/ (accessed 22 September 2025).

Ministry for the Environment 2025b. Consultation on updating RMA national direction. https://environment.govt.nz/news/consultation-on-updating-rma-national-direction/ (accessed 22 September 2025).

Ministry for the Environment 2025c. Fast-track Approvals Act. https://environment.govt.nz/acts-and-regulations/acts/fast-track-approvals/ (accessed 22 September 2025).

Ministry for the Environment 2025d. Fast-track approvals process. https://environment.govt.nz/acts-and-regulations/acts/fast-track-approvals/fast-track-approvals-process/ (accessed 22 September 2025).

Ministry for the Environment 2025e. Government climate-change work programme. https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/about-new-zealands-climate-change-programme/ (accessed 22 September 2025).

Ministry for the Environment 2025f. Independent climate adaptation report released. https://environment.govt.nz/news/independent-climate-adaptation-report-released/ (accessed 22 September 2025).

© New Zealand Institute for Bioeconomy Science Limited (2026)

Ministry for the Environment 2025g. A proposed approach for New Zealand's adaptation framework. https://environment.govt.nz/publications/adaptation-framework-a-proposed-approach-for-new-zealand/ (accessed 22 September 2025).

Ministry for the Environment 2025h. RM reform update – June 2025 (twenty-fifth edition). https://environment.govt.nz/news/resource-management-update-june/ (accessed 22 September 2025).

Mitchell R, Seymour M 2023. Meeting the needs of the sustainable finance sector: informing the Kaitiaki Intelligence Platform design. Kaitiaki Intelligence Platforms. https://static1.squarespace.com/static/6567cca035e84f7b802fa37b/t/66aac30a753d96276550832d/1722467149696/Meeting+the+Needs+of+the+Sustainable+Finance+Sectorpdf (accessed 30 April 2025)

Moewaka Barnes H, Harmsworth G, Tipa G, Henwood W, McCreanor T 2021. Indigenous-led environmental research in Aotearoa New Zealand: beyond a transdisciplinary model for best practice, empowerment and action. AlterNative: An International Journal of Indigenous Peoples 17(2): 306–316. https://doi.org/10.1177/11771801211019397

Moir J. 2024 August 1. Health NZ drops tool that factored in ethnicity for waitlists, despite review findings. RNZ. https://www.rnz.co.nz/news/political/523825/health-nz-drops-tool-that-factored-in-ethnicity-for-waitlists-despite-review-findings (accessed 31 October 2025).

Morgan TKKB, Reid J, McMillan OWT, Kingi T, White TT, Young B, Snow V, Laurenson S 2021. Towards best-practice inclusion of cultural indicators in decision making by Indigenous peoples. AlterNative 17(2): 202–214. https://doi.org/10.1177/11771801211015686

Morrison MA, Elliot S, Hughes A, Kainamu A, Williams E, Lowe M, Lohrer D, Needham H, Semadeni-Davies A 2023. Land-based effects on coastal fisheries and kaimoana and their habitats – a review. New Zealand Aquatic Environment and Biodiversity Report 309. Wellington, Fisheries New Zealand, Ministry for Primary Industries. https://www.mpi.govt.nz/dmsdocument/56425-AEBR-309-Land-based-effects-on-coastal-fisheries-and-kaimoana-and-their-habitats-a-review (accessed 30 April 2025)

Mullane T, Harwood M, Warbrick I, Tane T, Anderson A 2022. Understanding the workforce that supports Māori and Pacific peoples with type 2 diabetes to achieve better health outcomes. BMC Health Services Research 22(1): 672. https://doi.org/10.1186/s12913-022-08057-4

Muncaster S, McLellan G, Lovatt S, Murray J, Paruru D, Roskruge M, Ellis-Smith B, Hamer T, Coltman T, Paul-Burke K, Bird S 2024. A novel approach to aquaculture in Aotearoa New Zealand: growing community well-being with pātiki tōtara. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/A-novel-approach-to-aquaculture/A-novel-approach-to-aquaculture.pdf (accessed 30 April 2025)

Munro M 2021. Te Wairoa, Te Kāinga Tahi. Building Better Homes, Towns and Cities. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Munro_sept2021_te_wairoa_kainga_tahi.pdf (accessed 30 April 2025)

OpenAI 2025. ChatGPT (May 19 version) [Large language model]. https://chat.openai.com/chat

Our Land and Water 2021. Te Mana o te Wai: Te Tauihu case study report (Vol. 1). https://ourlandandwater.nz/wp-content/uploads/2022/02/TMOTW-Case-Study-Nga-Iwi-o-te-Tauihu.pdf (accessed 30 April 2025)

Palmer S, Mercier OR, King-Hunt A 2020. Towards rangatiratanga in pest management? Māori perspectives and frameworks on novel biotechnologies in conservation. Pacific Conservation Biology 27(4): 391–401. https://doi.org/10.1071/PC20014

Papa Pounamu 2022. Submission to MfE: draft national adaptation plan (Te mahere urutaunga ā-motu). Wellington, Ministry for the Environment. https://resiliencechallenge.nz/wp-content/uploads/Papa-Pounamu-Submission-to-MfE-draft-National-Adaptation-Plan-03June2022.pdf (accessed 30 April 2025)

Paul J 2023. Housing policy for rangatahi Māori: a discussion paper on shared equity homeownership. Building Better Homes, Towns and Cities. https://www.buildingbetter.nz/wp-content/uploads/2023/12/291123-FINAL_Housing-Policy-for-Rangatahi-Maori_-A-Discussion-Paper-on-Shared-Equity-Homeownersh.pdf (accessed 30 April 2025)

Paul J, Ratana M 2022. Youth homelessness in Tāmaki Makaurau, Aotearoa New Zealand: a scoping report prepared for Manaaki Rangatahi ki Tāmaki Makaurau Youth Homelessness Collective. Ngā Wai a te Tūī Māori and Indigenous Research Centre. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Paul_Ratana_july2022_youth_homelessness.pdf (accessed 30 April 2025)

Paul-Burke K, Ngarimu-Cameron R, Burke J, Bulmer R, Cameron K, O'Brien T, Bluett C, Ranapia M 2022. Taura kuku: prioritising Māori knowledge and resources to create biodegradable mussel spat settlement lines for shellfish restoration in Ōhiwa Harbour. New Zealand Journal of Marine and Freshwater Research 56(3): 570–584. https://doi.org/10.1080/00288330.2022.2111447

Percy H, Kingi T, Allen W, Tamepo R, Cichota R, Young B, White T 2024. Pohewa Pae Tawhiti: a Māori holistic approach to the co-design of land-use systems. Journal of the Royal Society of New Zealand 55(6): 2381-2399 https://doi.org/10.1080/03036758.2024.2427824

Pirini M 2024. Legal impacts of extreme weather events on Māori land and tikanga. Unpublished report.

Pohatu P, O'Brien S, Mercer L 2020. Challenges and opportunities with native forestry on Māori land. Motu Working Paper 20-13. Wellington, Motu Economic and Public Policy Research. https://doi.org/10.29310/wp.2020.13

Pohatu P, Walker K 2021. Waiapu Koka Huhua: a river flowing free – hapū leading Te Mana o te Wai. Poipoia Ltd. https://ourlandandwater.nz/wp-content/uploads/2022/02/TMOTW-Case-Study-Waiapu-Kokahuhua.pdf (accessed 30 April 2025)

Pourzand F, Bolton A, Salter C, Hales S, Woodward A 2023. Health and climate change: adaptation policy in Aotearoa New Zealand. The Lancet Regional Health–Western Pacific 40. 100954. https://doi.org/10.1016/j.lanwpc.2023.100954

Ratana M 2023. Room for rangatahi: housing security and rangatahi Māori. Building Better Homes, Towns and Cities. https://www.buildingbetter.nz/wp-content/uploads/2024/01/EDITED_FPE_12_Dec_2023_Room-for-Rangatahi-FINAL.pdf (accessed 30 April 2025)

Reid J, Rout M, Whitehead J, Katene T 2023. Tauutuutu: a white paper. Our Land and Water National Science Challenge. https://ourlandandwater.nz/wp-content/uploads/2024/01/Tauutuutu-White-Paper-Final-28-6.pdf (accessed 30 April 2025)

Resilience to Nature's Challenges 2024a. Insurance and disaster recovery: policy brief. Resilience to Nature's Challenges https://resiliencechallenge.nz/wp-content/uploads/Insurance-Policy-Brief.pdf (accessed 30 April 2025)

Resilience to Nature's Challenges 2024b. Psychosocial factors in disaster recovery: policy brief. Resilience to Nature's Challenges https://resiliencechallenge.nz/wp-content/uploads/Psycho-Social-Response-and-Recovery-Policy-Brief.pdf (accessed 30 April 2025)

© New Zealand Institute for Bioeconomy Science Limited (2026)

Rouchon AM, Phillips NE 2017. Acute toxicity of copper, lead, zinc and their mixtures on the sea urchin Evechinus chloroticus. New Zealand Journal of Marine and Freshwater Research 51(3): 333–355. https://doi.org/10.1080/00288330.2016.1239643

Rout M, Awatere S, Reid J, Campbell E, Huang A, Warmenhoven T 2025. Barriers to and opportunities for the restoration of mana in emergency management legislation and its implementation for Māori. Disasters 49(3): e12684. https://doi.org/10.1111/disa.12684

Rout M, Walker G 2021. An exploration of the Māori housing-health nexus during the mid-twentieth century. New Zealand Population Review 47: 70–107. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Rout_Walker_Aug2021_an_exploration_maori_housing-health_nexus.pdf (accessed 30 April 2025)

Rout M, Whitehead J 2023. Capturing premiums for authentic Māori agrifood products: consumer willingness to pay and authentication processes. Our Land and Water National Science Challenge. https://ourlandandwater.nz/wp-content/uploads/2024/08/CapturingpremiumsforauthenticMaoriagrifoodproducts.pdf (accessed 30 April 2025)

Rout M, Mika J, Reid, J, Whitehead J, Wiremu F, Gillies A, McLellan G, Ruha C 2023. Indigenising the blue economy in Aotearoa: a literature review. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/tools-and-resources/literature-review-indigenising-the-blue-economy/ (accessed 30 April 2025)

Rua M, Hodgetts D, Groot S, Blake D, Karapu R, Neha E 2023. A Kaupapa Māori conceptualisation and efforts to address the needs of the growing precariat in Aotearoa New Zealand: a situated focus on Māori. British Journal of Social Psychology 62: 39–55. https://doi.org/10.1111/bjso.12598

Salmond A, Brierley G, Hikuroa D, Lythberg B 2022. Tai timu, tai pari, the ebb and flow of the tides: working with the Waimatā from the mountains to the sea. New Zealand Journal of Marine and Freshwater Research 56(3): 430–446. https://doi.org/10.1080/00288330.2022.2096084

Schreier M 2012. Qualitative content analysis in practice. Sage Publications.

Sharma P, Martin M, Swanlund D, Latham C, Anderson D, Wood W 2024. A cloud-based solution for trustless Indigenous data sovereignty: protecting Māori biodiversity management data in Aotearoa New Zealand. Transactions in GIS 28(4): 836–857. https://doi.org/10.1111/tgis.13153

Short L, Craig D, McCowan T 2023. Upholding the value of pāua quota: summary report. Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/tools-and-resources/upholding-the-value-of-p%C4%81ua-quota/ (accessed 30 April 2025)

Skelton B, Rossieur TA, MacDonald N, Tawiri K, Jeffs A 2023. Creating a sustainable supply of seed mussels using mātauranga Māori (Kohunga Kūtai). Sustainable Seas National Science Challenge. https://www.sustainableseaschallenge.co.nz/assets/dms/Reports/Kohunga-Kutai/Creating-a-sustainable-supply-of-seed-mussels-using-matauranga-Maori.pdf (accessed 30 April 2025)

Stephenson J, Kawharu M, Bond S, Diprose G, Rereatukahia Marae Komiti, Maketu Iwi Collective, Te Kaahui o Rauru, Kati Huirapa ki Puketeraki, Aukaha 2023. Adaptation by mana whenua: initiatives, challenges, and working with councils. Centre for Sustainability, University of Otago. https://deepsouthchallenge.co.nz/research-project/innovations-for-climate-adaptation/ (accessed 30 April 2025)

© New Zealand Institute for Bioeconomy Science Limited (2026)

Stephenson J, Rewi P, McMillan H 2023. Adaptation by mana whenua: initiatives, challenges, and working with councils (interim report). Dunedin, Centre for Sustainability, University of Otago. https://deepsouthchallenge.co.nz/wp-content/uploads/2023/11/Adaptation-by-Mana-Whenua-initiatives-challenges-and-working-with-councils.pdf (accessed 30 April 2025)

Sweeney M, Breitenmoser T, Dickson I 2022. A pathway towards understanding Māori aspirations for land transport in Aotearoa New Zealand. Waka Kotahi NZ Transport Agency Research Report 688. Wellington, Waka Kotahi NZ Transport Agency. https://www.nzta.govt.nz/assets/resources/research/reports/688/688-a-pathway-towards-understanding-maori-aspirations-for-land-transport-in-new-zealand.pdf (accessed 30 April 2025)

Su B, Wu L 2020. Occupants' health and their living conditions of remote indigenous communities in New Zealand. International Journal of Environmental Research and Public Health 17(22): 8340. https://www.mdpi.com/1660-4601/17/22/8340

Taiapa K, Moewaka Barnes H, Wright S 2024. Climate change and mātauranga Māori: making sense of a Western environmental construct. Kōtuitui: New Zealand Journal of Social Sciences Online, 20: 405-416 https://doi.org/10.1080/1177083X.2024.2350195

Tai-o-Rongo Research Collective 2024. Harnessing kōrero tuku iho for flourishing land management at Awhi Farms. Ātihau-Whanganui Incorporation. https://ourlandandwater.nz/wp-content/uploads/2024/11/Tai-o-Rongo-Research-Report.docx.pdf (accessed 30 April 2025)

Tait-Wall W, Kora T, Awatere S, Makiha MR, Taylor L 2022. 21st century papakāinga: a blueprint for resilience. MAI Journal: A New Zealand Journal of Indigenous Scholarship 11(2): 167–181. https://doi.org/10.20507/MAIJournal.2022.11.2.7

Tane T, Selak V, Eggleton K, Harwood M 2022. Understanding the barriers and facilitators that influence access to quality cardiovascular care for rural Indigenous peoples: protocol for a scoping review. BMJ Open 12(12): e065685. https://doi.org/10.1136/bmjopen-2022-065685

Tapsell E 2022. Transitioning environmental governance in Aotearoa: tikanga Māori and a political ethic of care. Unpublished Master's thesis, Victoria University of Wellington, Wellington.

Te One A, Clifford C 2021. Tino rangatiratanga and well-being: Māori self-determination in the face of Covid-19. Frontiers in Sociology 6: 613340. https://doi.org/10.3389/fsoc.2021.613340

Te Poutoko Ora a Kiwa 2022. Final report summary: COVID-19 and national immunisation programme research. https://bpb-ap-se2.wpmucdn.com/blogs.auckland.ac.nz/dist/4/894/files/2025/10/prop-007-final-summary-report.pdf (accessed 30 October 2025)

Te Puni Kōkiri 2023. Understanding climate hazards for hapori Māori. Te Puni Kōkiri. https://www.tpk.govt.nz/en/mo-te-puni-kokiri/our-stories-and-media/understanding-climate-hazards-for-hapori-maori (accessed 30 June 2025)

Te Rūnanga o Ngāi Tahu Group 2024. Annual report 2023–2024. https://ngaitahu.iwi.nz/assets/Documents/TRONT-AR2024-comp.pdf (accessed 30 April 2025)

Te Rūnanga o Te Rarawa 2021. Cultural impact assessment: Kaitaia Wastewater Treatment Plant. Te Rūnanga o Te Rarawa. https://www.fndc.govt.nz/__data/assets/pdf_file/0024/16287/te-rarawa-cultural-impact-assessment-kaitaia-wastewater-treatment-may-2021-final.pdf (accessed 30 April 2025)

© New Zealand Institute for Bioeconomy Science Limited (2026)

Thompson T 2021. Young people's climate anxiety revealed in landmark survey. Nature 597(7878): 605-605. https://doi.org/10.1038/d41586-021-02582-8

UK Department for Science, Innovation and Technology 2024. AI-assisted vs human-only evidence review: results from a comparative study. https://www.gov.uk/government/publications/ai-assisted-vs-human-only-evidence-review (accessed 30 April 2025)

van Hamelsveld S, Kurenbach B, Paull DJ, Godsoe WA, Ferguson GC, Heinemann JA 2023. Indigenous food sources as vectors of *Escherichia coli* and antibiotic resistance. Environmental Pollution 334: 122155. https://doi.org/10.1016/j.envpol.2023.122155

van Meijl T 2020. Culture versus class: towards an understanding of Māori poverty. Race & Class 62(1): 78–96. https://doi.org/10.1177/0306396820923482

Waitangi Tribunal 2023. Wai 2575: health services and outcomes kaupapa inquiry. Wellington, Waitangi Tribunal. https://forms.justice.govt.nz/search/Documents/WT/wt_DOC_195476216/Hauora%202023%20W.pdf (accessed 30 April 2025)

Waitangi Tribunal 2021. Haumaru: the COVID-19 priority report (Wai 2575). Waitangi Tribunal. Wellington, Legislation Direct. https://www.waitangitribunal.govt.nz/assets/DOCUMENTS/Haumaru-W.pdf (accessed 30 April 2025)

Waitoki W, McLachlan A 2022. Indigenous Māori responses to COVID-19: he waka eke noa? International Journal of Psychology 57(5): 567–576. https://doi.org/10.1002/ijop.12849

Walker E, Wilcox M, Awatere S 2025. Reimagining, reclaiming, and reconnecting Indigenous voices in urbanism: a review of Indigenous approaches for urban ecological restoration. Humanities and Social Sciences Communications 12(1): 1–8. https://doi.org/10.1057/s41599-025-05065-7

Walter M, Kukutai T, Carroll SR, Rodriguez-Lonebear D eds 2021. Indigenous data sovereignty and policy. Routledge. https://doi.org/10.4324/9780429273957

Whaitua Te Whanganui-a-Tara Committee 2021. Te Whaitua Te Whanganui-a-Tara implementation programme. Wellington, Greater Wellington Regional Council. https://www.gw.govt.nz/assets/Documents/2021/12/Te-Whaitua-te-Whanganui-a-Tara-Implementation-Programme_web.pdf (accessed 30 June 2025)

Wheeler A, Rahiri JL, Ellison-Lupena R, Hanchard S, Brewer KM, Paynter J, Harwood M 2025. Assessing the gaps in cardiovascular disease risk assessment and management in primary care for Māori and Pacific peoples in Aotearoa New Zealand—a systematic review. The Lancet Regional Health–Western Pacific 56. https://doi.org/10.1016/j.lanwpc.2025.101511

White V, Ferguson A, Goodyear R, Saville-Smith K 2021. The condition of owned and rented housing in Aotearoa New Zealand. New Zealand Population Review 47: 108–144. https://www.buildingbetter.nz/publication/the-condition-of-owned-and-rented-housing-in-aotearoa-new-zealand/index.html (accessed 30 April 2025)

Whitehead J, Walker G 2021. Exploring the factors affecting Māori home ownership. New Zealand Population Review 47: 262–304. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Whitehead_Walker_Aug2021_exploring_the_factors_maori_home_ownership.pdf (accessed 30 April 2025)

Wilcox M, McKay A-M, Clifton TA, Marshall A 2024. Te Tirohanga o Ngā Tohu: Taranaki climate resilience tool development. Manaaki Whenua – Landcare Research Contract Report LC4441. Prepared for the Deep South National Science Challenge.

© New Zealand Institute for Bioeconomy Science Limited (2026)

https://deepsouthchallenge.co.nz/wp-content/uploads/2024/06/Te-Tirohanga-o-Nga-Tohu-Taranaki-Climate-Resilience-Tool-Development.pdf (accessed 30 April 2025)

Wood W, Lustig A, Latham MC, Anderson DP 2024. Mātauranga Māori framework for surveillance of plant pathogens. Frontiers in Forests and Global Change 7: 1392083. https://doi.org/10.3389/ffgc.2024.1392083

Yates AM 2021. Transforming geographies: performing Indigenous-Māori ontologies and ethics of more-than-human care in an era of ecological emergency. New Zealand Geographer 77(2): 101–113. https://doi.org/10.1111/nzg.12302

Yates A, Dombroski K, Dionisio R 2022. Dialogues for well-being in an ecological emergency: well-being-led governance frameworks and transformative Indigenous tools. Building Better Homes, Towns and Cities. https://www.buildingbetter.nz/wp-content/uploads/2023/08/Yates_et_al_jun2022_dialogues_for_well-being_in_an_ecological_emergency.pdf (accessed 30 April 2025)

Yletyinen J, Tylianakis JM, Stone C, Lyver POB 2022. Potential for cascading impacts of environmental change and policy on Indigenous culture. Ambio 51: 1110–1122. https://doi.org/10.1007/s13280-021-01670-3

© New Zealand Institute for Bioeconomy Science Limited (2026)

Glossary of Māori words/concepts (kupu Māori)

Kupu Māori (Māori word(s))	Definition
ahi kā	burning fires of occupation, continuous occupation
āhuarangi	climate
Aotearoa	New Zealand
aroha	to love, feel pity, feel concern for, feel compassion, empathise
awa	river, stream
awhi	to embrace
hapū	kinship group, tribe, subtribe; a kinship group descended from a common ancestor. The primary political unit in traditional Māori society.
haumaru	safe, risk-free
hīkoi	walk or march, often used to refer to protest walks or spiritual journeys
hapori	community
harakeke	New Zealand flax, *Phormium tenax*
hauora	be fit, well, healthy, vigorous, in good spirits, health, vigour
hirahira	great, important, of consequence, significant
hui	gathering, meeting, assembly, seminar, conference.
huringa	shift or change, commonly used in climate contexts (e.g., huringa āhuarangi)
ika	fish, marine animal, aquatic animal
iwi	tribe or people; a large kinship group descended from a common ancestor
kai	food
kaiāwhina	helper, assistant, contributor, counsel, advocate
kaimahi	worker, employee
kaimoana	seafood, shellfish
kāinga	home, village or settlement
kaitiaki	guardian or caretaker, often of the environment
kaitiakitanga	guardianship, especially environmental stewardship
kāpō Māori	Māori persons who are blind, have low vision, or a vision impairment.
karakia	prayer or incantation
kaumātua	elder or respected tribal leader
kaupapa	principle, philosophy, or approach (especially in Māori-led initiatives)
kaupapa Māori	Māori approach or approaches
kauri	kauri, *Agathis australis*
kaumātua	adult, elder
kina	sea egg, common sea urchin, *Evechinus chloroticus*
Kīngitanga	King Movement - a movement which developed in the 1850s, culminating in the anointing of Pōtatau Te Wherowhero as King.
kohunga kūtai	mussel spat
kōkā	mother, aunty - eastern dialect
kōrero	speech, narrative, story
kōura	salt-water crayfish, the southern rock lobster, red rock lobster, spiny rock lobster, *Jasus edwardsii*
kuku	green-lipped mussel, common mussel, *Perna canaliculus*

© New Zealand Institute for Bioeconomy Science Limited (2026)

Kupu Māori (Māori word(s))	Definition
kura	school, education
kūtai	mussel (of several species)
mahi	to work
mahi aroha	volunteer work
mahinga	place where work is done, activity, garden, fishery, cultivated area
mahinga kai	garden, cultivation, food-gathering place
mana	authority, prestige, spiritual power
mana motuhake	separate identity, autonomy, self-government, self-determination, independence
mana whakahaere	governance, authority, jurisdiction, management, mandate, power
mana whenua	territorial rights, power from the land, authority/jurisdiction over land or territory, power associated with possession and occupation of tribal land. Sometimes used to describe those associated with such rights/authority; or (more loosely) with tribal links to a specific area
manaaki	to support, take care of, give hospitality to, protect
manaakitanga	hospitality, generosity, care for others
mānuka	mānuka, tea-tree, *Leptospermum scoparium*
Māori	Māori, indigenous New Zealander, indigenous person of Aotearoa/New Zealand
marae	communal or sacred place that serves as a venue for community gatherings
māra kai	food garden
māramatanga	enlightenment, insight, understanding
maramataka	traditional lunar calendar used to guide planting, fishing, and other activities
mātauranga	knowledge, especially Indigenous Māori knowledge systems
mātauranga Māori	Māori knowledge
mauri	life principle, life force, vital essence
mea	thing, object, property
moana	sea, ocean, large lake
mokopuna	grandchild or descendant
ora	to be alive, well, safe, cured, recovered, healthy, fit, healed
oranga	livelihood, welfare, health
pae	horizon, perch, rest, orators' bench,
Pākehā	New Zealander of European descent
papakāinga	communal Māori housing or homestead on ancestral land
pātaka kai	pantry, food storage.
pāua	pāua, abalone, sea ear, *Haliotis* spp.
pipi	pipi, *Paphies australis* - a common edible bivalve
pou	post, upright, pillar, support, pole
poukai	King Movement gathering
pounamu	greenstone, nephrite, jade
pōwhiri	welcoming ceremony
Puna wai	spring or source, often used for water sources or metaphorically for origin
pūrakau	narratives
rangatahi	youth

© New Zealand Institute for Bioeconomy Science Limited (2026)

Kupu Māori (Māori word(s)	Definition
rangatiratanga	chieftainship, authority, self-determination; often used to express Māori sovereignty or leadership rights
rangi	sky
raranga	(verb) to weave, plat (mats, baskets, etc.) (noun) weaving
rātā	rātā, *Metrosideros robusta* (Northern), *Metrosideros umbellata* (Southern)
te reo Māori	the Māori language
rimurapa	bull kelp, d*urvillaea antarctica* often used traditionally for food preservation and containers
rohe	region or district, especially of an iwi or hapū
rongo, Rongo (Rongomātāne)	peace, harmony; also, the atua of cultivated food and agriculture
rongoā	traditional Māori medicine
rūnanga	council, tribal council, assembly, board, boardroom, iwi authority – assemblies called to discuss issues of concern to iwi or the community.
taiao	natural environment
tamariki	children
tāmure	snapper, *Chrysophrys auratus*
tangata	person or people
tangata whenua	people of the land; local Māori with ancestral ties to a particular place
tangihanga	mourning ceremony or funeral rites
taonga	treasured possessions, both tangible and intangible taonga species – cultural keystone species.
tapu	sacred, restricted
taura kuku	mussel spat lines (lines are of natural material such as harakeke or tī kōuka fibres)
Te Hiku o te Ika	Northland – especially the northern tip
Te Mana o te Wai	a concept referring to the fundamental importance of water and its health, recognised by the Ministry for the Environment in its policy documents and statements
Te Matau-a-Māui	Hawke's Bay
te ao Māori	Māori world view
Te Tairāwhiti	East Coast
Te Tai Tokerau	Northland, North Auckland
Te Tau Ihu	top of the South Island of New Zealand
Te Tiriti/Te Tiriti o Waitangi	The Treaty/The Treaty of Waitangi
Te Wairoa	a group of Ngāti Kahungunu and Ngāti Rongomaiwahine Māori hapū
Te Whaitua te Whanganui-a-Tara	A Greater Wellington programme to restore and improve water quality and ecosystem health
tiaki	care, protect, conserve
tika	truth, correctness, directness, justice, fairness, righteousness, right
tikanga	correct procedure, protocol, customs
tino rangatiratanga	self-determination, sovereignty, autonomy
tipu/tupu	plant, to grow, sprout, or shoot (often used interchangeably with *tupu*)
tohu	sign or symbol
tohunga	an expert
tuangi (also called huangi, tuaki)	Littleneck clam, commonly called 'cockle', *Austrovenus stutchburyi*

© New Zealand Institute for Bioeconomy Science Limited (2026)

Kupu Māori (Māori word(s))	Definition
tuna	eel of various species, including the longfin eel (*Anguilla dieffenbachii*) and shortfin eel (*Anguilla australis*)
urupā	cemetery or burial ground
wāhi tapu	sacred place, sacred site
wāhi tīpuna/wāhi tūpuna	ancestral place
wāhine	women, females (singular wahine)
wāhine Māori	Māori women
wai māori	freshwater
Waiapu River	a river and catchment in Te Tairāwhiti
Waikato	tribes living in the Waikato Basin, also the name of the river from which they take their name
wairua	spirit or soul; the spiritual dimension of a person or environment
wairuatanga	spirituality
wānanga	tribal knowledge, lore, learning, and the place of learning
whakapapa	genealogy, lineage; the layering of relationships that connect people, places, and knowledge systems
whare	house, building, residence, dwelling, shed, hut, habitation
wharenui	meeting house, large house
wharekai	dining hall, refectory, cafe, restaurant
whare tīpuna/tūpuna	ancestral house or building
whenua	land; also refers to placenta, symbolising the deep connection between Indigenous people and place
whenua Māori	land subject to the Te Ture Whenua Māori Act 1993
whenua tuku iho	inherited land
whānau	extended family, family group
whanaungatanga	kinship, relationships

Sources: Te Aka Dictionary, https://maoridictionary.co.nz/
Names for places, concepts and names not in Te Aka, provided by authors.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Glossary of initialisms and acronyms

AI	Artificial Intelligence
AUT	Auckland University of Technology
BBHTC	Building Better Homes, Towns and Cities National Science Challenge
BioH	Biological Heritage National Science Challenge
BSI	Bioeconomy Science Institute
CCVA	Climate Change Vulnerability Assessment
CIA	Cultural Impact Assessment
COVID	Coronavirus Disease
DSC	Deep South Challenge National Science Challenge
ETS	Emissions Trading Scheme
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Government policy statement on health 2024-2027
GWL	Global Warming Level
MBIE	Ministry of Business, Innovation and Employment
MMFS	Mātauranga Māori Framework for Surveillance
MPI	Ministry for Primary Industries
MWLR	Manaaki Whenua Landcare Research
NAP	National Adaptation Plan
Ngā Pae o te Māramatanga	Aotearoa's Māori Centre of Research Excellence
NES	National Environmental Standards
NPS	National Policy Statement
NCCRA	National Climate Change Risk Assessment
OLW	Our Land and Water National Science Challenge
PCE	Parliamentary Commissioner for the Environment
RCP	Representative Concentration Pathway
RMA	Resource Management Act
Te Poutoko Ora a Kiwa	Centre for Pacific and Global Health (Auckland University)
WAI	Waitangi Tribunal claim prefix (e.g. WAI 262)

© New Zealand Institute for Bioeconomy Science Limited (2026)

Appendix 1 – NCCRA analytical template

© New Zealand Institute for Bioeconomy Science Limited (2026)

NCCRA analytical template: <Risk [Domain]>

Ref:	NCCRA 2026	Status:	Draft
Domain(s):	<E.g. Natural environment>		
Author:			
Last updated:		QA:	

Using this template:

- Complete one NCCRA analytical template for each risk.
- There are two parts to the template, each starts with drafting guidance (for risk severity, and policy readiness).
- Highlighted text includes guidance on the **level of detail** we are looking for in each section, and **examples**. Replace that highlighted text with your assessment. You should aim to cover all the key elements listed, although there are some exceptions where certain sections of the template may not apply to all risks.
- **Reference** the information with end notes (full citation) and save the references.
- **Save** each completed template in the correct folder.

Part one: Risk severity

Drafting guidance:

- **Information gathering**: Please use the first National Climate Change Risk Assessment as a starting point and *update and add* to the information as needed. You may also want to refer to the reference list at the end of the report if you are struggling to find information on a particular risk.
- Other key sources of information will be academic journal articles, IPCC AR6 (particularly the Australasia chapter), the new MfE downscaled climate projections, National Science Challenge research reports (for example, Deep South or Resilience to Nature's Challenges), the work done by Aotearoa Circle on sector-specific climate change scenarios, information from researchers, commissioned studies by councils and government agencies, etc.
- In particular, you will want to look for sources of information that have come out since 2020 (when the first NCCRA was published), as this will help to get a sense of how the risks we face or our understanding of them may have changed since the publication of the first NCCRA.
- **Definition of risk**: risk is the interaction between hazard, exposure and vulnerability (sensitivity and adaptive capacity).

© New Zealand Institute for Bioeconomy Science Limited (2026)

- **Assessment criteria**: You are asked to assess the current and future risk (or opportunity) and its consequences.
  - *Future risk* should be assessed using evidence for mid-century (ideally 2050) and the end of the century (ideally 2090), and that ideally relates to global warming levels (GWLs) equivalent to 1.5°C and 2/2.5°C (mid-century) and 2°C and 3/3.5°C (end of century).
  - These GWLs are consistent with low and high emissions pathways such as SSP1–2.6 and SSP3–7.0, but what's important for us to consider from an adaptation perspective is the climate impact of these scenarios (with SSP1–2.6 having a comparatively low climate impact and SSP3–7.0 having a comparatively high climate impact).
  - However, it's okay if the information doesn't correspond exactly to those timeframes and GWLs. What's important is that we have information that corresponds to both a low climate impact scenario and a high climate impact scenario, for both the middle of the century and the end of the century.

Time horizon	Global Warming Level	Corresponding scenarios
2050	GWL1.5 (low impact) GWL2/2.5 (high impact)	SSP1–2.6 (low emissions) SSP3–7.0 (high emissions)
2090	GWL2 (low impact) GWL3/3.5 (high impact)	SSP1–2.6 (low emissions) SSP3–7.0 (high emissions)

- **Timeframe, scenario/GWL, uncertainty and tail-end risks**: You need to report the time period and scenario/GWL for the evidence cited, and document the uncertainty. Please capture and report on any tail-end risks, including low-probability high-consequence extremes (events).
- **Writing style**: Text from this template will be used as the basis for chapter text. You can write as bullet text using full sentences, or as short paragraphs. It is okay to use sub-headings where needed to organise your text.

© New Zealand Institute for Bioeconomy Science Limited (2026)

- Keep your language as plain as you can, avoiding technical terms and abstractions when possible.

Assessment of risk severity

Risk Summary	Key elements to cover: • Summarise the risk and what elements it includes. • Identify the sub-risks that make up the risk. • Identify any elements that are out of scope for this risk. Examples: "New Zealanders are already experiencing physical health impacts from climate hazards such as wildfire, floods, heatwaves, droughts and storms (Jones et al, 2014b). These hazards are projected to increase in frequency and severity." "Sub-risks include direct and indirect risks to physical health from extreme weather events such as heatwaves, wildfires and flooding, direct risks to physical health from zoonotic and water-borne diseases, indirect risks to physical health from the impact of drought and heavy rainfall events on water availability and quality."
Climate hazards that drive this risk	☐ Sea level rise and coastal flooding ☐ River and surface flooding ☐ Shoreline change and coastal erosion ☐ Storms, and extreme rain and wind ☐ Changing rain and wind patterns ☐ Heatwaves, cold snaps and rising average temperatures ☐ Drought and dry spells ☐ Wildfires and changing fire weather ☐ Ocean warming and acidification ☐ Landslides ☐ Other – please specify:

© New Zealand Institute for Bioeconomy Science Limited (2026)

Exposure – Current, 2050 and 2090	This is likely to be the longest section (multiple paragraphs, up to a page in length). Key elements to cover: • What is Aotearoa New Zealand's current exposure to the risk? • What is Aotearoa New Zealand's exposure to the risk projected to be in mid-century (ideally 2050) for GWLs of approximately 1.5°C and 2/2.5°C? • What is Aotearoa New Zealand's exposure to the risk projected to be by the end of the century (ideally 2090) for GWLs of approximately 2°C and 3/3.5°C? • How much uncertainty is there in the available information? • Are there any significant changes in the information since the first NCCRA? Note: Don't get too hung up on finding information that corresponds exactly to the timeframes and global warming levels listed. What's important is that we have information that corresponds to both a low emissions scenario and a high emissions scenario, for both the middle of the century and the end of the century. Examples: "X number of buildings are currently exposed to coastal flooding for a 1% AEP (annual exceedance probability[5]) event." "X number of buildings will be exposed to coastal flooding for a 1% AEP event with 20cm of sea level rise." "Under 3 degrees of warming globally, at 2090 X number of buildings will be exposed to coastal flooding." "Under warming of about 2 degrees Celsius from pre-industrial temperatures, a 1-in-20-year drought could occur at least twice as often in eastern parts of New Zealand." What we aren't looking for: "Under RCP 4.5, X number of buildings will be exposed to coastal flooding." "Under SSP3-7.0, X number of buildings will be exposed to coastal flooding."
Sensitivity and adaptive capacity	This section should also contain multiple paragraphs, up to a page in length. Key elements to cover: • How sensitive are relevant individuals, communities, systems, networks or other things New Zealanders value to the risk, and what is their adaptive capacity to respond to the risk? • How much uncertainty is there in the available information? • Are there any significant changes in the information since the first NCCRA? Examples: "The Health National Adaptation Plan, released by the Ministry of Health in October 2024, notes that the groups most affected by climate change impacts include young people, rangatahi, children and future generations, Māori, Pacific peoples, disabled people, rural populations and people living with high levels of socioeconomic deprivation." "Communities whose livelihoods depend on the natural environment are sensitive to events which disrupt those livelihoods." "The ability to adapt is affected by socioeconomic factors such as age, gender, social networks and social capital."

[5] Annual Exceedance Probability (AEP) is the probability of a certain sized flood occurring in a single year.

	"In general, people living in poverty are more sensitive to the impacts of climate change hazards." "Horticulture is very sensitive to water availability at critical times of the growing season." "Ecosystems and species with greater tolerance to periodic exposure to saline waters, and those with some degree of dispersal ability, are likely to have a greater adaptive capacity." "The sensitivity of linear transport networks to extreme weather depends on the physical condition of the assets, local ground conditions, and design of the infrastructure itself."
Does this risk have significant impacts for iwi/Māori?	Aim for 1–3 paragraphs. Key elements to consider: • Is the risk of particular significance to Māori? • Does the risk particularly relate to Māori interests, values and practices? • There is some information on this in the first NCCRA, and the report *He huringa āhuarangi, he huringa ao: a changing climate, a changing world* may also be useful. Examples: "The risk of exacerbating existing inequities and creating new and additional inequities will have a disproportionate impact on Māori, due to the socioeconomic disparities between Māori and non-Māori communities."
Compounding or cascading factors[6]	Aim for 1–3 paragraphs. Key elements to cover: • How does the risk interact with other risks? • Is the risk a result of other risks, or is it a risk that will drive other risks? • Please refer to specific risks (not just general domains) that influence or are influenced by the risk. Examples: "Risk to the terrestrial environment will impact the risks to livestock agriculture and horticulture, which will have flow on effects for the risks to the economy and to mental health." "Road networks provide critical access to lifeline utilities (power, water, gas, telecommunications, health care) and other essential services. Any disruption to transport can lead to significant cascading consequences for people, such as making it more difficult to access emergency medical care." "The interaction between climate hazards, social cohesion and community wellbeing has the potential to increase the vulnerability of people and their communities to climate change. Loss of land and households will exacerbate physical and mental health issues, affect peoples' sense of belonging and identity, and perpetuate inequity, adversely impacting social cohesion."
Socioeconomic trends that may exacerbate the risk	Aim for 1–3 paragraphs. Key elements to consider: • Document any social, economic or demographic trends that could increase or decrease the severity of the risks (noting that for some risks, there may not be any trends that impact their severity). This backgrounder may be useful in considering socioeconomic trends.

[6] Cascading effects (of climate change) are the effects that flow on from a primary hazard to compound and affect many systems in a dynamic sequence.

	Examples: "Aotearoa New Zealand has an ageing population, which will exacerbate the risks to physical health from climate change over time. Older people (aged 65 or older) are more vulnerable to climate hazards, particularly changes in temperature (extreme heat) and extreme weather events."
Climate thresholds and tipping points that may exacerbate the risk	Aim for 1–3 paragraphs. Key elements to consider: • Document thresholds, whether biophysical thresholds, engineering, performance or policy thresholds, that could impact the severity of the risk (for example, where adaptive capacity of the element at risk might be exceeded)[7]. Does exceedance of these vary over scenarios or across projections (uncertainty)? • Document tipping points, which refer to critical thresholds in a system that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the change is irreversible. More information is available here (ice sheet collapse and changing ocean circulation are of particular relevance for this risk assessment). Examples: "Tipping points may be reached with the ice sheets, which will exacerbate sea level rise and impact many risks." "Extreme heat causes buckling of rail lines when XX temperatures are reached."
Possible interactions with climate mitigation actions	Aim for 1–3 paragraphs. Key elements to consider: • Document any possible interactions with climate mitigation actions. Is the climate mitigation action likely to increase or decrease the magnitude of the risk/opportunity? Could the climate change risk or opportunity make the climate mitigation action easier or harder to achieve? Examples: "If pine trees are planted in areas that will become increasingly at risk from wildfires, this would mean areas of forest used to absorb emissions could be lost to wildfire (which would also release greenhouse gases). This could impact the country's ability to meet its emissions budgets and target."
Regional differences	Aim for 1–2 paragraphs. Key elements to consider: • Are there significant regional differences in exposure, sensitivity and/or adaptive capacity? • Is the risk particularly elevated in an individual region(s), such that it would increase the overall scoring for the risk? • Note: we expect that this won't be the case for most risks. If it is not the case for your risk, you can mark this section Not Applicable. Examples: "Erosion in Gisborne, drought in Canterbury, Northland, Hawke's Bay."
Data gaps	Aim for 1–3 paragraphs or a short bullet point list. Key elements to cover: • Are there significant gaps in evidence for this risk? In terms of exposure, sensitivity and adaptive capacity for each of the hazards that impact the risk.

[7] For example, in assessing the impacts of increased environmental temperatures, threshold temperatures might be established when asset behaviour significantly changes

© New Zealand Institute for Bioeconomy Science Limited (2026)

	• Is the risk likely to be more consequential than the available information would suggest? • Are there data gaps that were highlighted in the first NCCRA that still haven't been addressed? Examples: "There are gaps in knowledge in terms of understanding the specific vulnerability of a wider range of individual ecosystems and species."
Sources of information considered	Key elements to cover: • List the sources of information you consulted in pulling together the information in this section of the template. • Include sources of information that weren't useful to you as well as sources that were. Examples: • The first National Climate Change Risk Assessment • IPCC Sixth Assessment Report Australasia chapter • He huringa āhuarangi, he huringa ao: a changing climate, a changing world Deep South research papers (list them).
Confidence level	Aim for 1–2 paragraphs. Key elements to cover: • Summarise the strength, quality and quantity of the available evidence for this risk. • Summarise the level of agreement within the evidence for this risk. • Note that we will make a formal assessment of confidence at a later date, ensuring consistency in how the confidence level is assessed across all the risks. Examples: "There is robust evidence and a high level of agreement that climate change will adversely impact the physical health of New Zealanders. More evidence is needed around the impacts and their geographical spread."
Summary of risk severity	Key elements to cover: • Brief overall summary of risk severity evidence. • Any key points that might influence the assessment. • Consider key differences in risk elements (exposure, sensitivity, etc.) for mid-century vs end of century and low emissions vs high emissions. Does exposure (and therefore risk) change significantly depending on timeframe and global warming level, or is the risk less sensitive to changes in scenarios?

Part two: Policy readiness

Drafting guidance:

- This section assesses the degree to which existing and planned adaptation actions will contribute to addressing the risk.
- **Information gathering**: As a starting point, refer to the IEB six-monthly reporting and the first National Adaptation Plan Progress Assessment (Chapters 6, 7, 8 and 9 in particular).
- Document the changes in adaptation action that have occurred since the first NCCRA was published.

© New Zealand Institute for Bioeconomy Science Limited (2026)

- Document the potential reduction in future risks (or the realisation of future opportunities) from the planned adaptation actions in place. This should also consider if government action involves potential maladaptation, or could result in lock-in of risks.
- For the section 'Other actions signalled', please list (in bullet form) any other actions signalled or indicated, but not yet announced by a Minister or in an official government document.

Assessment of policy readiness

What policies and actions are currently in place to support adaptation to this risk?	Key elements to cover: • List the current or planned (confirmed) adaptation policies and actions that contribute to addressing the risk. • Group actions according to the actor – e.g. central government, local government, private sector, communities, iwi/Māori. • Consider whether the actions listed might have co-benefits or may interact negatively with climate mitigation actions. Examples: "An adaptation framework is being developed." "X councils have developed coastal hazards tools and maps." "X councils have an adaptation plan in place or under development."
Other actions signalled	Key elements to cover: • List any other adaptation actions signalled or indicated but not yet announced. Please include the source of this information. • If there are no actions which fall into this category, mark this box Not Applicable. Examples: "MfE has indicated in a conversation that they may be doing a piece of work on the risks to XX. This has not been officially confirmed yet."
What other adaptation actions could be taken to address this risk?	Key elements to cover: • Summarise adaptation actions that could significantly contribute to addressing this risk. • Describe potential adaptation actions that could be taken, but do not be prescriptive on new policy. • Document the evidence on possible actions. • Consider whether the actions identified might have co-benefits or may interact negatively with climate mitigation actions. Examples: "Buildings can be raised to be above flood levels in urban areas that use nature-based solutions to better cope with flood events." "Farmers can provide shelter for livestock to help reduce the impact of heat waves on animal health."
Do the policies and actions that are currently in place appropriately consider the	Key elements to cover: • Do the planned policies and actions take into account the specific effects of climate change on iwi and Māori, and do they recognise and take into account Māori perspectives? Examples:

© New Zealand Institute for Bioeconomy Science Limited (2026)

specific effects on iwi and Māori?	"The Māori Climate Platform is being developed in partnership with tangata whenua to assist Māori-led climate action, planning and solutions. A Ministerial Advisory Committee was appointed to engage with Māori and lead the design phase of the platform, but based on announcements in Budget 2024, the future of the platform remains uncertain."
What are the barriers to adaptation?	Key elements to cover: • Summarise any key barriers in relation to this risk that are contributing to a lack of action or are inhibiting or delaying action to address the risk. Examples: "Common challenges to adaptation relate to institutional and legislative settings, clarity around how the costs of adaptation and loss will be shared and met, and access to data, information and tools."
Policy horizon	Key elements to cover: • Is there potential lock-in of risks or loss of opportunities, particularly in the coming six years? • Describe whether or not addressing the risk requires long lead times, meaning that action would need to start earlier to avoid locking in the risk. Examples: "Without a clear mandate to avoid development in locations that will become increasingly exposed to natural hazards as the climate changes, we will continue to build in these locations and lock in future exposure to the risks."
What is the shortfall – what are the benefits to further action in the next six years?	Key elements to cover: • Considering the potential reduction in future risks / realization of future opportunity from the planned adaptation in place, assess if there is a shortfall where planned adaptation actions will fail to fully address the risk (and how large the shortfall is). List what further actions could be taken in the next six years that would contribute to reducing this risk. Examples: "There are no actions in the first National Adaptation Plan specifically targeted at addressing the risks of exacerbating existing inequities and creating new and additional inequities due to differential distribution of climate change impacts. The actions included in the plan that relate to this risk are all indirect, and therefore unlikely to adequately address the risk." "A funding framework is needed that sets out how to share costs for the range of potential adaptation options, including nature-based solutions, hard engineered solutions, or relocation."
Data gaps	Key elements to cover: • Are there significant gaps in evidence of actions being undertaken for this risk? • Provide these as a short bullet point list. Examples: "There is a lack of publicly available information regarding adaptation actions being undertaken by the private sector."
Sources of information considered	Key elements to cover: • List the sources of information you consulted in pulling together the information in this section of the template.

	Include sources of information that weren't useful to you as well as sources that were.
Summary of policy readiness	Key elements to cover: • Brief overall summary of policy readiness evidence. • Any key points that might influence the assessment.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Appendix 2 – NCCRA risk severity rating criteria exemplar

© New Zealand Institute for Bioeconomy Science Limited (2026)

Governance Risk Severity Rating Criteria

	Minor	Moderate	Major	Extreme
Overarching	• Minor and infrequent losses and damages • No significant disturbance of system functionality. • Temporary and/or very slow onset impacts. • Unlikely to pose systemic risk.	• Moderate and/or recurring losses and damages • Moderate disturbance of system functionality. • Medium term and/or slow onset impacts. • Some potential to pose systemic risk.	• Large and/or frequent losses and damages • Major and/or long-term disturbance of system functionality. • Long term and/or rapid onset impacts. • Potential for impact thresholds or local tipping points to be reached, posing systemic risk	• Very large and/or very frequent losses and damages • Total and/or irreversible loss of system functionality. • Permanent and/or very rapid onset impacts. • High potential for impact thresholds or local tipping points to be reached, very likely to pose systemic risk.
Extent, duration and frequency of likely impacts	• Some minor impacts on decision-making functions, service delivery, and community resilience, at the local level. • Some tensions within or between levels of government with some impact on public trust.	• Moderate and/or frequent impacts on decision-making functions, service delivery and community resilience, at the local or regional level. • Rising tensions within or between levels of government compromising public trust and leading to unrest and litigation.	• Major and frequent multifunctional impacts on decision-making functions, service delivery and community resilience, at a regional or national level. • Partial institutional failure significantly impacting public trust and leading to major and frequent unrest and loss of social cohesion.	• Extreme multifunctional, cascading and compounding impacts at the national level, that compromise the ability of all levels of government to govern and provide services. • Severe institutional failure causing near total loss of public trust, and leading to frequent community unrest, violence, major disruption, and/or threats to the rule of law.
Ability to recover from likely impacts	• Recovery possible using existing institutional settings or decision-making processes, no enduring structural or relational/reputational damage.	• Recovery requires policy or organisational change, but existing mandates and relationships remain largely intact, with some reputational damage.	• Restoration requires legislative reform, cross-government intervention, or rebuilding of governance relationships. • Entrenched misalignment or distrust present.	• Governance failure has led to irreversible decisions. System legitimacy or authority is no longer recoverable through standard processes
Likely equity impacts	• Decision-making and service provision do not materially reinforce existing inequities or disproportionately impact Māori or other groups. • Decision-making and service provision do not materially concentrate impacts on locations/communities already experiencing or recovering from climate impacts • Decision-making processes are largely inclusive.	• Decision-making and service provision may reinforce existing inequities or disproportionately affect Māori or other groups. • Decision-making and service provision may concentrate impacts on locations/communities already experiencing or recovering from climate impacts • Decision-making processes partially exclude or disadvantage some groups.	• Decision-making and service provision are likely to strengthen existing inequities or disproportionately affect Māori or other groups. • Decision-making and service provision are likely to concentrate impacts on locations/communities already experiencing or recovering from climate impacts. • Highly exclusionary decision-making processes amplify structural inequities.	• Decision-making and service provision are almost certain to reinforce existing inequities or disproportionately affect Māori or other groups in significant and enduring ways. • Decision-making and service provision are almost certain to concentrate impacts on locations/communities already experiencing or recovering from climate impacts. • Deep, systemic exclusion leading to failure of democratic processes.
Likely impacts on te ao Māori	• Exclusion from planning may constrain effective response; Māori-led strategies are under-resourced.	• Exclusion from planning may constrain effective response; Māori-led strategies are under-resourced	• Compounding exclusion across systems; Māori governance sidelined as climate risks grow	• Compounding exclusion across systems; Māori governance sidelined as climate risks grow

© New Zealand Institute for Bioeconomy Science Limited (2026)

Appendix 3 – NCCRA overall risk severity ratings template

Overall risk severity ratings

Risk Severity Scores Under Different Climate Scenarios

	Present day	2050	2090 – GWL2	2090 – GWL 3/3.5
	Its current impact/consequence level	Its likely impact/consequence level by mid-century (2050)	Its likely impact/consequence level by the end of the century (2090) under a low climate impact scenario	Its likely impact/consequence level by the end of century (2090) under. A high climate impact scenario.
System coherence-adaptation system	Moderate	Major	Major	Extreme
	Moderate – Some incoherence in national direction and coordination, but partially mitigated by institutional resilience.	Major – Greater fragmentation likely as reforms lag, with climate complexity testing coordination mechanisms.	Major – Institutional disconnection entrenched, with knock-on effects for all domains if coherent policy and statutory frameworks aren't adopted.	Extreme – Systemic incoherence undermines investment, planning, and political stability across adaptation domains.
Effective implementation	Moderate	Major	Major	Extreme
	Moderate – Capacity issues and system strain are already affecting delivery in some councils.	Major – Compound stress on systems with increasing hazard exposure and adaptation delivery demands.	Major – Localised delivery failure expected in high-risk or under-resourced areas, but national systems still partially responsive.	Extreme – Governance systems fail to manage widespread and overlapping adaptation needs, leading to national-level dysfunction.
Upholding te Tiriti o Waitangi	Moderate	Major	Extreme	Extreme
	Existing legislative and funding gaps, but some Treaty-aligned processes are underway	Growing inequities and procedural failures likely as climate pressures rise and Treaty issues remain unresolved.	Risk of institutional erosion due to persistent failure to embed Māori governance, despite clear pressure to act.	Failure to uphold Treaty rights leads to systemic exclusion, breakdown of trust, and widespread procedural illegitimacy.
Social legitimacy of democratic institutions	Major	Major	Extreme	Extreme
	Moderate – Public trust is varied, but procedural legitimacy mostly holds with tensions emerging in key areas.	Public trust increasingly strained as adaptation decisions disproportionately affect vulnerable communities.	Major – Deepening polarisation and procedural legitimacy erosion across regions with contested climate adaptation.	Extreme – Institutional trust collapses; democratic legitimacy fails amid public unrest and political fragmentation.

© New Zealand Institute for Bioeconomy Science Limited (2026)

Appendix 4 – Policy readiness scorecard template

© New Zealand Institute for Bioeconomy Science Limited (2026)

Policy readiness assessment criteria

Policy readiness scorecard

Assessment of policy readiness for the risk

- Policy readiness criteria (based on different dimensions) – used to evaluate the likely policy readiness for this risk

	No significant gaps/Minor (for assessment of policy shortfall)	Moderate gaps	Significant gaps	Insufficient
Policy rating (all domains)	Policy coverage The risk is well covered and no significant gaps in policy/action remain. Policies respond well to the risk. Risk is clearly addressed in one or more policies and/or plans (national, local, etc) with direct actions. Readiness to implement / deliver Policies and plans have clear mandates, resourcing, and capable institutions. Implementation is likely to proceed effectively. Mandate, funding, and lead agencies are clear and active.	Policy coverage Aspects of the risk are covered, but some gaps in action remain. Policies and actions only partially respond to this risk. Policy mentions or touches the risk but lacks depth, detail or mandate. Readiness to implement / deliver Some delivery risks present – e.g., unclear mandate, uneven capacity (regional variation), or coordination issues, but partially supported. Some delivery underway, but gaps in mandate or uneven support.	Policy coverage Some important aspects of the risk are not well covered, and gaps in policy and action remain. Policy has not responded well to some important aspects of this risk. Some related policy exists but doesn't target this risk well. Readiness to implement / deliver Major delivery shortfalls. For example, institutional fragmentation, unclear responsibilities, lack of resources. Implementation is unlikely without significant changes. Fragmented responsibility, unclear mandate, or missing delivery structures.	Policy coverage The risk is not well covered, and very significant gaps in policy and action remain. Policy is either absent or has not responded to this significant risk. Risk is not mentioned or has no relevant national-level policy. Readiness to implement / deliver No realistic pathway for implementation. Lacks mandate, funding, and institutional support. Cannot be delivered under current conditions. No mandate, funding, or mechanism for delivery.

© New Zealand Institute for Bioeconomy Science Limited (2026)

	Policy shortfall – minor/insignificant Policies, plans, and actions, if fully delivered, would substantially address the risk. Only minimal risk remains. Risk largely mitigated by full implementation.	Policy shortfall – moderate Some risk would remain despite full implementation – for example, limits to policy scope, residual exposure. Some exposure remains (e.g., slow uptake, vulnerable populations).	Policy shortfall – major Policies, plans and actions would leave major parts of the risk unaddressed, even if implemented as intended. Major impacts would still occur due to limitations in scope or reach.	Policy shortfall – extreme Implementation would not reduce the risk meaningfully. Risk to people, systems or assets remains extremely high. Even with full implementation, core risk is not reduced.

© New Zealand Institute for Bioeconomy Science Limited (2026)