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Adapting to Avoidable and Unavoidable Climate Change

what must Aotearoa New Zealand do?

Abstract

The Intergovernmental Panel on Climate Change report *Climate Change 2022: impacts, adaptation and vulnerability* gives a stark warning of the urgency to adapt to avoidable and unavoidable climate change impacts and to transition to a more climate-resilient future. Aotearoa New Zealand has made some progress in setting up the institutional and planning frameworks for adaptation, but implementation is slow. Delay will increase the adverse consequences for humans and ecosystems, widen the adaptation gap, and increase the cost and damage burden to current and future generations, and those least able to adjust. Taking proactive actions today to avoid further exposure will enable a fairer and more robust and effective path for adaptation. Here we develop a report card for Aotearoa New Zealand's adaptation effort and recommend what we must do next.

Keywords climate change impacts, adaptation, vulnerability, climate-resilient development, institutional change, decision making, implementation

The Intergovernmental Panel on Climate Change (IPCC) Working Group II report *Climate Change 2022: impacts, adaptation and vulnerability* (IPCC, 2022a), released on 28 February, delivered a stark warning. In the words of IPCC chair Hoesung Lee, 'Our actions today will shape how people adapt and nature responds to increasing climate risks' (IPCC, 2022b). Any further delay in concerted global action will miss a brief and rapidly closing window to secure a liveable future. The report concludes that for every region of the world, at current rates of adaptation planning and implementation, the gap between what is needed for adaptation and what is delivered will continue to grow. As adaptation options often have long implementation times, long-term planning and accelerated implementation, particularly in the next decade, are critical to close adaptation gaps.

This report, and the Working Group I report on the physical science basis (IPCC, 2021), demonstrate that we have a good understanding of the likely impacts of climate change and recognise the interdependence of climate, biodiversity and people. While the magnitude and timing of impacts depend in part on the success of emissions reductions,

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the Australasia chapter of the report (Lawrence, Mackey et al., 2022a) summarises the observed and projected impacts for New Zealand. Cascading and compounding impacts[1] are increasingly a feature of changing climate and these underline the pressing need to build capacity and capability to move beyond incremental adaptation.

What can Aotearoa New Zealand learn from this body of evidence and the key messages for policymakers, and what must we do now? Governance is the critical lever for addressing these challenges, accelerating adaptation and helping to close the adaptation gap. Effective adaptation is inclusive and supported by accountable leadership to mobilise capabilities and resources and resolve disputes. It is enabled by legislation and procedures to provide clarity of purpose and to address fairness, equity and social vulnerability. Flexible governance is essential to change strategies, investment perspectives and policies leading to action, and that enhances the ability to organise and act collectively, and to learn to recognise and respond prudently to change before adaptation thresholds are reached. Such features of effective governance can help to address the low awareness amongst decision makers, communities and individuals of the scope and scale of the impacts of changing climate and their consequences. Furthermore, such governance must address the mismatch of scales and temporal decision making, and socio-economic inequalities and vulnerabilities, that can produce non-action or delayed action that counter effective adaptation.

A new feature of this sixth assessment is that the IPCC has now firmly linked mitigation with adaptation. The report calls attention to the rapidly closing adaptation gap caused by the delay in emissions reductions over many decades and the already built-in commitment to impacts yet to be felt (in the case of sea level rise for many centuries). Delay in reducing emissions means adaptation limits are reached sooner and adaptation options are reduced.

The report also places strong emphasis on the role of indigenous peoples, and their traditional environmental knowledge and understanding. In Aotearoa New Zealand the indigenous concept of kaitiakitanga has been embedded in environmental management since 1991, along with recognition of the principles of the Treaty of Waitangi. These components can be expected to become far more influential in future decision making in addressing ongoing climate change issues and risks.

In this article we examine adaptation policy and implementation in Aotearoa New Zealand in light of the report.

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What are the observed and projected impacts?

Climate change is no longer something that will occur in the future. Observed changes and impacts are summarised in the report and shown in Table 1. Together with future projected impacts, this information can inform a strategy for accelerating the adaptation required.

Cascading, compounding and aggregate impacts of climate change are new risks for Aotearoa New Zealand cities, settlements, infrastructure, productivity, supply chains and services. Floods, droughts, wildfires, heatwaves, storms and sea level rise have been recognised as discrete implications of a warming world. However, their interactions are now being observed. For example, extreme snow, heavy rainfall and wind events have already combined to affect road networks, power and water supply, interdependent waste water and storm water services and business activities. Sea level rise has created similar cascading impacts across sectors and communities. Climate risks, exacerbated by underlying vulnerabilities and exposures, are projected to increase for a wide range of systems and sectors and for Māori and other communities.

How have we adapted to climate hazards in Aotearoa New Zealand to date?

Historically, adaptation in Aotearoa New Zealand has been embedded in natural hazard management and water and soil conservation that seek to protect people from nature's variability and 'surprises', usually following 'events' (Lawrence, Sullivan et al., 2015; White and Lawrence, 2020). Large investments by central government and local government in stopbanks and sea walls were made across Aotearoa New Zealand earlier last century, which enabled cities and settlements and associated economic activities to develop largely unabated. Such structures have saved lives, but have also created a false sense of security, leading to intensification of development and activities reliant on their protection (Lawrence, Sullivan et al., 2015). Residual risks are inevitably increasing, but largely ignored by the public and decision makers alike. These kinds of 'hard' engineering adaptations in a changing climate risk context have a defined lifetime, even though they bring near-term benefits until adaptation thresholds are reached. They can create new problems along the coast, such as 'end effects', and interfere with sediment supply, leading to loss of beach amenity, and increase erosion. Where protection measures encourage more development the risk increases, accelerating the need to move from incremental to transformational change (e.g., in low-lying coastal areas, where hazards compound or where droughts become increasingly severe). Such 'maladaptation'[2] can include sea walls or irrigation schemes that prolong a false sense of security and lock in further urban and rural development as climate impacts worsen.

Adaptation is typically reactive after major events, supported by emergency management funding through the Earthquake Commission (EQC),[3] the Ministry for Primary Industry's adverse events policy for the rural sector,[4] and the Local Authority Protection Programme for water infrastructure damage from natural disaster.[5] Such funding has acted as social insurance to enable a return to life as usual in the same exposed locations as

Table 1. Changes since the last IPCC assessment in New Zealand

Observed changes and impacts	Examples
Ongoing climate trends have exacerbated many extreme events.	Further warming and SLR, more hot days and heatwaves, less snow, more rainfall in the south, less rainfall in the north and more extreme fire weather in the east.
Climate trends and extreme events have combined with exposure and vulnerabilities to cause major impacts for many natural systems, with some experiencing or at risk of irreversible change.	In the Southern Alps, from 1978 to 2016, the area of 14 glaciers declined 21%, and extreme glacier mass loss was at least 6 times more likely in 2011 and 10 times more likely in 2018 due to climate change.
Climate trends and extreme events have combined with exposure and vulnerabilities to cause major impacts for some human systems.	Socioeconomic costs from climate variability and change have increased. Extreme heat has led to excess deaths and heavy rainfall has increased rates of serious illnesses. Nuisance and extreme coastal flooding have increased due to SLR superimposed upon high tides and storm surges in low-lying coastal and estuarine locations, including impacts on cultural sites, traditions, and lifestyles of Tangata Whenua Māori. Droughts have caused financial and emotional stress in farm households and rural communities. Tourism has been negatively affected by poor ski seasons and receding glaciers. Governments, business, and communities have experienced major costs associated with extreme weather, droughts and SLR.
Climate impacts are cascading and compounding across sectors and socioeconomic and natural systems.	New types of risks have been generated, exacerbating existing stressors and constraining adaptation options e.g., cascading effects of disruption of interdependent systems and infrastructure in cities and settlements due to heavy rainfall events, SLR, groundwater rise, and heat.
Projected impacts and key risks	
Increasing climate risks are projected to exacerbate existing vulnerabilities and social inequalities and inequities.	These include inequalities between Māori and non-Māori and between generations, rural and urban areas, income, and health status, increasing the climate risks and adaptation challenges faced by some groups and places.
Further climate change is inevitable, with the rate and magnitude largely dependent on the emission pathway.	Projections include ongoing warming with more hot days and fewer cold days, further SLR, ocean warming and ocean acidification; more winter and spring rainfall is projected in the west and less in the east and north, with more summer rainfall in the east and less in the west and central North Island; ongoing glacier retreat and increased drought frequency is projected for southern and northern Aotearoa New Zealand respectively.
Ongoing climate trends have exacerbated many extreme events.	The Aotearoa New Zealand trends include further warming and SLR, more hot days and heatwaves, less snow, more rainfall in the south, less rainfall in the north and more extreme fire weather in the east.
Climate risks are projected to increase for a wide range of systems, sectors, and communities, which are exacerbated by underlying vulnerabilities and exposures.	*Key risks for Aotearoa New Zealand* *Ecosystems at critical thresholds, where recent climate change has caused significant damage and further climate change may cause irreversible damage, with limited scope for adaptation* • Insufficient evidence for Aotearoa New Zealand (see knowledge gaps below) *Key risks that have potential to be severe but can be reduced substantially by rapid, large-scale and effective mitigation and adaptation* • Loss of kelp forests in southeast Aotearoa New Zealand due to ocean warming, marine heatwaves and overgrazing by climate-driven range extensions of herbivore fish and urchins • Loss of natural and human systems in low-lying coastal areas due to SLR, for example for 0.5 m SLR, the value of buildings in Aotearoa New Zealand exposed to 1-in-100-year coastal inundation could increase by NZ$12.75 billion *Key cross-sectoral and system-wide risk* • Cascading, compounding and aggregate impacts on cities, settlements, infrastructure, supply chains and services due to wildfires, floods, droughts, heatwaves, storms and SLR, for example in Aotearoa New Zealand, extreme snow, heavy rainfall, and wind events have combined to impact road networks, power and water supply, interdependent wastewater and stormwater services and business activities *Key implementation risk* • Inability of institutions and governance systems to manage climate risks, for example the scale and scope of projected climate impacts overwhelm the capacity of institutions, organisations, and systems to provide necessary policies, services, resources, and coordination to address socioeconomic impacts

Observed changes and impacts	Examples
There are important interactions between mitigation and adaptation policies and their implementation.	• Integrated policies in interdependent systems across biodiversity, water quality, water availability, energy, transport, land use and forestry for mitigation can support synergies between adaptation and mitigation. There are co-benefits for the management of land use, water, and associated conflicts and for the functioning of cities and settlements. The projected increases in fire, drought, pest incursions, storms and wind place forests at risk and affect their ongoing role in meeting New Zealand's emissions reduction goals.

quickly as possible, rather than building adaptive capacity and the potential for transformation as the risks intensify with changing climate. Governments, banks and insurers have underwritten the risks and spread the costs across the public and local government, thus muting the deterrent effect for change (Lawrence and Saunders, 2017). More recently, signals from insurers and reinsurers are emerging that they are considering either larger excesses or withdrawal of cover for certain classes of 'foreseeable' risk, as damage from climate-related events becomes more frequent, sea level rise impacts escalate, and costs increase due to the escalating exposure of people and their assets to climate-related risks.

Additionally, attention to adaptation has until recently been crowded out by an almost singular focus on reducing emissions through market instruments (e.g., the Emissions Trading Scheme) and carbon offsets, without a comprehensive suite of complementary adaptation policies and regulations to support New Zealand's response to the adaptation remit in the Paris Agreement and the Climate Change Response (Zero Carbon) Amendment Act. Despite the focus on emissions, Aotearoa New Zealand's emissions have been trending up for decades, contributing to an even greater adaptation burden. The IPCC warns: 'Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all' (IPCC, 2022c).

The consequences of delaying action

The consequences of delay in reducing emissions are stark. For example, even transiently exceeding 1.5°C in the coming decades or later means that many human and natural systems will face additional severe risks compared to remaining below 1.5°C, and have irreversible consequences even if global warming is eventually reduced (ibid.).

Delaying adaptation action will result in higher future costs when adaptation becomes more urgent and the impacts more extreme. The costs of climate change impacts could become significant: evidence from Aotearoa New Zealand is very limited, but we know that floods have already cost the economy at least NZ$140 million for privately insured damages between 2007 and 2017, and two droughts alone that were attributable to climate change cost NZ$800 million (Frame et al., 2020). Damage costs from the projected increased frequency and intensity of floods and droughts will rise: the value of buildings exposed to coastal inundation could increase by NZ$2.55 billion for every 0.1m increment of sea level rise (Paulik et al., 2020).

While historically the government is seen as the insurer of last resort (Boston and Lawrence, 2018), the increasing frequency and intensity of impacts and associated damage may reduce the ability of the government to perform this role. The *National Climate Change Risk Assessment* (Ministry for the Environment, 2020) identifies 'Risks to governments from economic costs associated with lost productivity, disaster relief expenditure and unfunded contingent liabilities due to extreme events and ongoing, gradual changes' as a priority risk. Analysis in the IPCC report indicates that in the absence of investment in adaptation to reduce exposure and vulnerability, the risks will be passed over time from the public sector to the private sector and individuals (New et al., 2022). Combined with potential insurance retreat, this will render many populations increasingly vulnerable, exacerbating existing inequalities and potentially creating poverty 'traps' (Mechler et al., 2022).

Early action also provides an opportunity to address many of the existing challenges, including social inequality, enhancing the natural environment and biodiversity, improving urban spaces and increasing social cohesion. Identifying areas for synergies with emissions reductions and other goals can reduce costs and the administrative burden. The IPCC report emphasises that adaptation is most effective if climate change responses are integrated across all policy areas, rather than comprising a single-issue policy focus.

How can Aotearoa New Zealand adapt effectively and equitably?

The report sets out a range of adaptation options that are available and their limits within a fast-closing window of opportunity. Adaptation to climate change is much more than a single set of actions at a single point in time. Rather, it must be an ongoing cycle of assessment, action, reassessment, learning and response (New et al., 2022). Without this broader consideration and re-evaluation, many of the current adaptation actions in Aotearoa New Zealand will reach adaptation limits as the climate risks increase (e.g., sea walls, beach renourishment, dune plantings for protection; raising floor levels and land to accommodate the risks) (Lawrence, Allan and Clarke, 2021). Transformational adaptations such as changes in land use and planned and managed retreat are inevitable for some risks – coastal and riverine flooding and rising groundwater, extreme rainfall and drought – and require land use planning now based on strategies for reducing the impacts of climate disruption.

A stocktake of climate change adaptation resulting in 21 recommendations to guide adaptation action was completed in 2018 (Climate Change Adaptation Technical Working Group, 2017, 2018) in anticipation of the adaptation remit emerging. This contributed to the adaptation architecture that is now in place via the Climate Change Response (Zero Carbon) Amendment Act. The first Aotearoa New Zealand national climate change risk assessment has been completed (Ministry for the Environment, 2019, 2020). The Climate Change Act provides for national adaptation plans and the first is due in 2022. An independent Climate Change Commission was set up at the end of 2019 which is empowered to monitor the effectiveness and progress of adaptation in New Zealand. These provide the foundations for addressing the remaining recommendations of the Climate Change

Adaptation Technical Working Group for adapting to climate change in Aotearoa New Zealand; the information to support decision making, the building of capability and capacity and the funding to do the job are still to be addressed and leadership is yet to emerge for a planned and coordinated approach to adaptation action across central and local government agencies.

Ironically, planning to avoid and reduce risk from the effects of climate change has been possible for some years under the Resource Management Act 1991 (RMA) via natural hazards and climate change provisions, including the New Zealand Coastal Policy Statement, which must be given effect in policies and plans. The national coastal hazard and climate change guidance (last revised in 2017) gives specific guidance on addressing sea level rise, storm surge, erosion, associated coastal flooding and rising groundwater, for example. The Civil Defence Emergency Management Act expressly provides for risk reduction from natural hazards, and like the New Zealand Coastal Policy Statement adopts the precautionary principle even where there is uncertainty about the risks.

However, the potential of the RMA and the Civil Defence Emergency Management Act to help avoid increasing climate risks has not been realised, despite several councils attempting to address the rising risks (see examples below). With this context of inaction and delay around climate change adaptation, a review of the RMA (Resource Management Review Panel, 2020) highlighted the gaps in the current system. It recommended three new Acts: a Strategic Planning Act, a Natural and Built Environments Act and a Climate Change Adaptation Act (the latter mainly to address managed retreat property and funding gaps). The first two Acts are currently being drafted, while the Climate Change Adaptation Act is on a slower path. Any attempts to separate adaptation from strategic and spatial planning would make integration of climate change adaptation throughout policy areas more difficult. As emphasised by the IPCC report, integration is essential for effective adaptation.

Significantly, the RMA review acknowledged that the current static planning framework and practices are not well suited to addressing changing climate risks and that a more dynamic, adaptive approach is needed that can leverage more transformational change in land uses. This is where there are ongoing and increasing physical risks for ecosystems and habitation around our coasts and estuaries from sea level rise and compound coastal flooding (including rising groundwater and drainage challenges). The review elaborated on the types of legal instruments needed to bring about such changes. At the heart of these are powers relating to land use change and property ownership to address legacies from past decisions, stranded assets, and the need to avoid increasing ongoing exposures and vulnerabilities: for example, powers to acquire and modify existing land uses and consents and to acquire land; the power to use taxes, subsidies and other economic instruments to incentivise climate-resilient land and resource use; cost sharing and compensation governed via equity principles; and decision processes and measures that can enable legitimate engagement with communities and Māori. All are controversial issues yet to be navigated into law (Iorns, 2022).

Some progress has been made by some regional and district councils, and by a few government agencies, as they revise their plans and consider climate risks (Lawrence, Mackey et al., 2022a, 2022b; Lawrence, Allan and Clarke, 2021). However, to date progress has mainly been in planning, rather than implementation. Where implementation has occurred, it is largely incremental and retrospective, after extreme events.

The Civil Defence Emergency Management framework and funding through EQC have been largely short-term response focused, rather than looking to the long term for risk reduction and adaptive opportunities. Across other statutes the gaze is 30 years out – for example, infrastructure planning – with 50 years for building consents. Only very recently have climate change impacts featured: for example, in the National Policy Statement on Urban Development, and here it is relatively weak and poorly connected to other decision-making instruments.

However, default priorities continue in the crowded national policy statement space. Because of a lack of integration and policy coherence, the current short-term housing imperative is likely to override climate change considerations, despite clear principles for investment being available (e.g., the Climate Change Commission's principles for Covid-19 recovery).[6] The climate change imperatives appear distant in comparison with the immediate need to provide housing affordably or respond to a pandemic. This emphasises the criticality of integrating climate change throughout all policy areas, so that the longer-term implications for emissions reductions and adaptation are factored into decisions.

The Civil Defence Emergency Management framework and funding through EQC have been largely short-term response focused, rather than looking to the long term for risk reduction and adaptive opportunities.

Effective policy would set out responses to identified risk thresholds in advance, using triggers and/or threshold limits and stated actions that will be taken when those limits are reached (as in a dynamic adaptive policy pathways (DAPP) process). Every decision matters. On a sunny day nuisance tidal flooding looks ephemeral and inconsequential. Accommodating it may seem a satisfactory approach. More considered implications, such as long-term access to sites and buildings, the implications of extreme localised events ('weather bombs'), and the effectiveness of infrastructure such as gravity drainage and sewerage systems and underground coastal septic tanks, are often overlooked but become major problems as sea levels or flood exposures rise (Kool et al., 2020). Given the limited funds, it is essential that adaptation investment is prioritised to be efficient, effective and equitable (Boston and Lawrence, 2018).

The challenge for decision makers is that policy interventions and investments to avoid ongoing legacy effects from climate risks (damage, disruption and loss) to the things humans value and to nature will be required long before severe damages are experienced – although damage, disruption and loss are already being observed. Sea level rise poses a

distinctive and severe adaptation challenge as it implies dealing with gradual onset changes and increased frequency and magnitude of extreme coastal events which will escalate in the next few decades in low-lying areas (Stephens, Bell and Lawrence, 2018). Protection, accommodation, and advance and planned relocation responses are more effective if combined and/or sequenced, planned well ahead, aligned with sociocultural values and development priorities, and underpinned by inclusive community engagement processes (IPCC, 2022c; Haasnoot, Lawrence and Magnan, 2021).

Conventional decision-making processes and tools are seldom suitable as they do not account for the long time frames, the range of potential futures or the cascading and compounding impacts identified in the IPCC report (Dittrich, Wreford and Moran, 2016; Lawrence, Bell and Stroombergen, 2019; Lawrence, Haasnoot et al., 2019). Increased intensity and frequency of the climate risks make a strategic long-term approach to adaptation implementation essential. New institutions and laws cannot on their own effect the change needed to respond to the IPCC assessment without a public conversation that is built on an understanding of the rising risks and who bears them. Such a conversation is long overdue in a pluvial and maritime country with the majority of its citizens living close to the coast or on floodplains and where the inequalities that make us vulnerable are obvious to see.

Effective adaptation was defined in the 2017 Climate Change Adaptation Technical Working Group stocktake as adaptation that reduces risks substantially, avoids losses and maximises opportunities.

What might effective adaptation look like

It is one thing to identify climate risks and vulnerabilities. It is quite another to bridge to an effective adaptation strategy and to ensure that the strategy provides for ongoing responses to changing circumstances and increasing risks.

Effective adaptation was defined in the 2017 Climate Change Adaptation Technical Working Group stocktake as adaptation that reduces risks substantially, avoids losses and maximises opportunities. Three enablers for these outcomes were set out. It is instructive to reflect on what has been achieved in the five years since that report.

- Adaptation has to be well informed about how climate is changing and what that means for Aotearoa New Zealand: *we can gauge this now, albeit with some significant gaps, but we have no coordinated means by which to disseminate information and regularly update it.*
- There must be an organised and consistent approach to adaptation: *the foundations are in place or being built, but capacity, capability and coordinated practice are not.*
- Taking dynamic action is essential to proactively manage the environmental, economic and social risks: *in Aotearoa New Zealand there are a few examples of applied adaptive planning, a New Zealand Coastal Policy Statement and national coastal hazards and climate change guidance, and decision tools are available, but uptake is too slow compared with the climate changes that must be anticipated before adaptation limits are reached.*

The IPCC report frames the characteristics of adaptation as justice, feasibility and effectiveness – *just* to the extent that the adaptations respect the principles of distributive, procedural and recognitional justice; *feasible* to the extent it is considered possible and desirable, taking into consideration barriers, enablers, synergies and trade-offs; and *effective* to the extent it reduces risk.

The Australasia chapter of the report (Lawrence, Mackey et al., 2022a) encapsulates the learning over the intervening years since the previous assessment. The report card is that:

- while the ambition, scope and progress of adaptation has increased, progress is uneven due to gaps, barriers and limits to adaptation, and adaptive capacity deficits;
- a step change in adaptation from incremental to more transformative adaptation is needed to match the rising risks and to support climate-resilient development;
- delay in implementing adaptation and emissions reductions will impede climate-resilient development, resulting in more costly climate impacts and greater scale of adjustments;
- climate-resilient development integrates adaptation measures and their enabling conditions with mitigation to advance sustainable development for all.

Effective adaptation is dependent on enablers and gaining social legitimacy as far as is possible. The report concluded that shifting from reactive to anticipatory planning, integrating across decision domains, and coordination across levels of government and sectors are necessary enablers for effective adaptation. However, it also concluded that inclusive and collaborative institutional arrangements, government leadership, policy alignment, nationally consistent and accessible information, and decision support tools are part of a suite of enablers that also include adaptation funding and finance and robust, consistent and strategic policy commitments (Table 2).

Attitudes to climate change are changing in New Zealand, with the majority now agreeing that it is real and caused by humans (Milfont et al., 2021) – a good basis from which to build climate change literacy further through the use of more systemic, collaborative and future-oriented engagement approaches in local contexts (Rouse et al., 2017; Ministry for the Environment, 2017). These go hand in hand with dedicated expert organisational support (Climate Change Adaptation Technical Working Group, 2018; Salmon, 2019) (see Box 1). But such enablers depend on adequate resourcing and being able to measure progress and effectiveness of adaptation (Table 2).

How can the RMA reforms accelerate adaptation action?

The new structures for regional spatial planning, which involve larger regions and more streamlined decision making, provide the prospect of effective and consistent identification of areas likely to be subject to hazards and risks from climate change. This will assist in identifying areas which must be excluded from further development and prioritising other most vulnerable areas for urgent adaptive planning action, thus addressing avoidable and unavoidable climate

change impacts. The regional spatial plans can also identify and integrate long-term framework planning for infrastructure across all levels of government and the private sector. They establish a platform for more detailed regional and district land use planning, including environmental protection measures such as restoring natural coastal protection and retreat of development in response to rising seas.

We are yet to see how the new legislation will provide for long-term planning using DAPP assessment and decision processes in vulnerable areas. The existing New Zealand Coastal Policy Statement, which already provides an excellent national policy framework for adaptation in coastal areas, must be carried through under the new legislation. Further national guidance (through national policy statements and model policy and rules) is essential so that addressing climate change effects is prioritised, including identifying areas where unavoidable climate change effects require that any further development or land use intensification are prohibited. Enablers missing in action currently include legislative alignment for the Building Act, and new property constructs to address existing uses and where risks progress spatially across marine and terrestrial areas as boundaries change. The proposed Strategic Planning Act needs to override other statutes that may otherwise provide for use and development in areas of climate risk.

However, planning decisions continue to be made in the meantime and the new legislation may take years to be given effect. To avoid further legacy effects from current decision making, transitional provisions need to be in place. This should include urgent clarification in the National Policy Statement on Urban Development that land likely to be subject to climate change effects within the next 100 years should be excluded from urban intensification as a qualifying matter under that policy. Immediate changes to the RMA should put on hold changes in land use and unimplemented consents in areas of climate

BOX 1 Approaches to building climate literacy and capability

- Local 'adaptation champions' and experimental and tailored engagement processes can enhance learning.
- Dynamic adaptive pathways planning (DAPP) and inclusive community governance can help progress difficult decisions, such as the relocation of cultural assets and managed retreat, and contestation about which public goods or values to prioritise, and show how adaptation can be implemented.
- Participatory climate change scenario planning can test assumptions about the present and the future and help envision people-centred, place-based adaptation.
- Social network analysis can inform engagement and communication of adaptation.
- Knowledge brokers, information portals and alliances can help communities, governments and sector groups to better access and use climate change information.

Source: Lawrence et al ., 2022a

Table 2. Enablers for measuring progress and effectiveness of adaptation

Enabler	Example	Report card
Governance frameworks	• Clear climate change adaptation mandate • Measures that inform a shift from reactive to anticipatory decision-making (e.g., decision tools that have long time frames) • Institutional frameworks integrated across all levels of government for better coordination • Revised design standards for buildings, infrastructure, landscape such as common land use planning guidance and codes of practice that integrate consideration of climate risks to address existing and future exposures and vulnerability of people and physical and cultural assets	• Institutional foundations in place or being developed • Continuation of ad hoc single-issue planning • Coordinated governance frameworks emerging for some risks (3 waters; freshwater management; health institutions; local government reform) • Some design standards emerging but single issue focused and uncoordinated across sectors • Some councils have updated regional policy statements and regional and district plans aligned with the NZCPS. For example: – Marlborough Unitary Council has embedded adaptive policy in its proposed Marlborough Environment Plan. – Northland Regional Council has set out detailed policy and adaptive approaches for more detailed planning in collaboration with district councils and affected communities.
Building capacity for adaptation	• Provision of nationally consistent risk information through agreed methodologies for risk assessment that address dynamic change and uncertainty • Targeted research including understanding the projected scope and scale of cascading and compounding risks • Education, training, and professional development for adaptation under changing risk conditions • Accessible adaptation tools and information	• No coordinated training and professional development programmes in place to build climate change literacy nationally • No one stop shop portal/s where updated climate change information and expert advice can be accessed • Risk methodologies developed and being used by councils to develop regional risk assessments • Decision tools for dynamic and uncertain impacts available but uptake is slow • Methodologies available for assessing cascading and compounding impacts but uptake slow • Further development needed of cascading and compounding impacts methodologies that are simple to use and digitised and open source

Enabler	Example	Report card
Community partnership and collaborative engagement	• Community engagement based on principles that consider social and cultural and Indigenous Peoples' contexts and an understanding of what people value and wish to protect (e.g., International Association of Public Participation methodologies) • Use of collaborative and learning-oriented engagement approaches tailored for the social context and informed by the cultural context • Community awareness and network building • Building on Tangata Whenua Māori communities' social-cultural networks and conventions that promote collective action and mutual support	• Uptake of collaborative community engagement has been too slow given the rising risks • Declaration of climate emergencies has spurred the setting up of climate change action committees and groups to collaborate with councils • Membership of engagement groups typically include local Iwi and hapū to residents, non-governmental organisations, business interests and youth • Councils and DOC support of coastal care groups with the Coastal Restoration Trust of New Zealand is an example of coordinated community collaboration with cultural and science experts and practical resources through community networking • Enhancement of knowledge and understanding of the effects of climate change through community networking to enhance coastal buffering and improvements to local biodiversity
Dynamic adaptive decision making	• Increased understanding and use of decision-making tools to address uncertainties and changing risks, such as scenario planning and DAPP to enable effective adaptation as climate risk profiles worsen	• DAPP uptake too slow for timely and effective adaptation • A small number of councils and government agencies (e.g., DOC, Waka Kotahi, have started using DAPP for coastal planning, transport and asset planning which has raised awareness of the utility of DAPP for anticipatory planning. For example: • Marlborough Unitary Council has included provision in its proposed Marlborough Environment Plan to progress DAPP planning as a method for vulnerable communities. • Northland Regional Council used DAPP to scope out its climate change risks and options. • Hawkes Bay coastal councils used DAPP to chart options, pathways, in its development of the Tangoio-Clifton Coastal Hazards Strategy and signals and triggers for implementation of the Strategy. • DOC used DAPP to plan for impacts to huts from glacier melt and moraine erosion.
Funding mechanisms	• Adaptation funding framework to increase investment in adaptation actions • New private-sector financial instruments to support adaptation	• Adaptation Act with funding and property instruments on a slower track so barriers remain further delaying effective adaptation • Private sector initiatives for funding emissions reductions but slow to develop similar for adaptation investment • Major barrier remains around who pays and how • Funding models exist for ad hoc responses e.g., leaky buildings, Matata but none address the scale of climate change impacts evidenced in IPCC, 2022
Reducing systemic vulnerabilities	• Economic and social policies that reduce income and wealth inequalities • Strengthening social capital and cohesion • Identifying and redressing rigid or fragmented administrative and service delivery systems • Reviewing land use and spatial planning to reduce exposure to climate risks • Restoring degraded ecosystems and avoiding further environmental degradation and loss.	

Source: adapted from Lawrence, Mackey et al., 2022a

risk, address the fraught issue of existing use rights, and provide that new rules have immediate effect in such areas. Additional changes are needed to align statutory timelines for prioritising vulnerabilities and use of DAPP, and for establishing a monitoring regime using signals and triggers with the Climate Change Response (Zero Carbon) Amendment Act monitoring timelines of the national adaptation plan and next national climate change risk assessment (Lawrence, Allan and Clarke, 2021).

Knowledge gaps for effective adaptation

Successive IPCC and national assessments (Climate Change Adaptation Technical Working Group, 2018) have highlighted for Aotearoa New Zealand the paucity of information about climate change impacts

on natural system dynamics in terrestrial, freshwater and marine ecosystems. Addressing these gaps is now urgent to support effective resource management and conservation activity.

New information gaps have emerged from the report across two areas relevant to accelerating adaptation in Aotearoa New Zealand: understanding complexity and uncertainty in observed and projected impacts, and supporting adaptation decision making. These include:

- the exposure and vulnerability of different groups within society, including indigenous peoples;
- the relationships between emissions mitigation and adaptation, especially where land carbon mitigation is affected by climate change;
- the effectiveness, longevity and feasibility of different adaptation options;
- the social transitions needed for transformative adaptation;
- the enablers for new knowledge to better inform decision making (e.g., monitoring data and repositories, integrated risk and vulnerability assessments, robust planning approaches, sharing adaptation knowledge and practice for more rapid adaptation).

Mātauranga Māori

Aotearoa New Zealand is uniquely placed to enhance effective adaptation through mātauranga Māori about climate change planning that promotes collective action and mutual support across New Zealand. Tangata whenua Māori are grounded in mātauranga Māori, which is based on human–nature relationships and ecological integrity and incorporates practices used to detect and anticipate changes taking place in the environment, a major theme of the report.

Sociocultural networks and conventions that promote collective action and mutual support are central features of Māori communities, and these customary approaches are critical to responding to, and recovering from, adverse environmental conditions (Hikuroa, 2020). Intergenerational approaches to planning for the future are also intrinsic to Māori sociocultural organisation and are expected to become increasingly important, elevating political discussions about conceptions of rationality, diversity and the rights of non-human entities in climate change policy and adaptation.

The report concluded that supporting tangata whenua Māori institutions, knowledge and values enables self-determination and creates opportunities to develop adaptation responses to climate change to the benefit of all in New Zealand. Active upholding of the United Nations Declaration on the Rights of Indigenous Peoples and Māori interests under the Treaty of Waitangi at all levels of government enables intergenerational approaches for effective adaptation to be adopted.

Conclusion

Aotearoa New Zealand faces an extremely challenging future that will be highly disruptive for many human and natural systems (IPCC, 2018, 2021, 2022b; United Nations Environment Programme, 2020). The extent to which the limits to adaptation are reached depends on whether global warming peaks this century at 1.5°C, 2°C or 3°C+ above pre-industrial levels. Additional warming beyond 1.5°C this century will result in irreversible impacts on certain ecosystems with low resilience. For Aotearoa New Zealand this means alpine, ocean and coastal ecosystems impacted by warming and glacier melt or by accelerating and higher committed sea level rise. Risks to human systems will increase, including those to infrastructure, low-lying coastal settlements, some ecosystem-based adaptation measures, and associated livelihoods and cultural and spiritual values.

The IPCC report stresses the interdependence of adaptation and emissions mitigation, and that delaying either or both will impede climate-resilient development and result in more costly climate impacts and greater scale of adjustments. Avoiding increasing the risks requires robust, timely and effective adaptation as well as significant and rapid emissions reductions to keep global warming to 1.5°C–2°C. The projected warming under current global emissions reduction and adaptation policies would leave many of New Zealand's human and natural systems at high risk, and in some cases potentially beyond adaptation limits.

Integrated and inclusive adaptation decision-making and statutory processes can contribute to climate-resilient development by better mediating competing values, interests and priorities and helping to reconcile short- and long-term objectives, as well as public and private costs and benefits, in the face of rapidly and continuously changing risk profiles. The scale and scope of societal change needed to transition to more climate-resilient development pathways requires close attention to governance, ethical questions, the role of civil society and the place of tangata whenua Māori in the co-production of ongoing adaptation at multiple scales.

1 The summary report notes that 'multiple climate hazards will occur simultaneously, and multiple climatic and non-climatic risks will interact, resulting in compounding overall risk and risks cascading across sectors and regions' (IPCC, 2022c, B5).

2 Maladaptation refers to actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.

3 The Earthquake Commission Act 1993 provides insurance funding for residential property damage from natural disasters, administered by the Earthquake Commission, which is funded through a levy on private property insurance for underwriting damages up to NZ$150,000 per claim.

4 See https://www.mpi.govt.nz/funding-rural-support/adverse-events/planning-for-natural-disasters-and-other-adverse-events/.

5 See http://lapp.org.nz/. The Local Authority Protection Programme (LAPP) disaster fund is a cash accumulation mutual pool for fund members for post-event funding, with a central government/ local government 60:40 split for infrastructure repairs and clean-up costs after a threshold is reached.

6 https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/six-principles-for-economic-recovery.

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References

Boston, J. and J. Lawrence (2018) 'Funding climate change adaptation: the case for a new policy framework', *Policy Quarterly*, 14 (2), pp.40–9

Climate Change Adaptation Technical Working Group (2017) *Adapting to Climate Change in New Zealand: stocktake report from the Climate Change Adaptation Technical Working Group*, Wellington: Ministry for the Environment

Climate Change Adaptation Technical Working Group (2018) *Adapting to Climate Change in New Zealand: recommendations from the Climate Change Adaptation Technical Working Group*, Wellington: Ministry for the Environment

Dittrich, R., A. Wreford and D. Moran (2016) 'A survey of decision-making approaches for climate change adaptation: are robust

methods the way forward?', *Ecological Economics*, 122, https://doi.org/10.1016/j.ecolecon.2015.12.006

Frame, D.J., S.M. Rosier, I. Noy, L.J. Harrington, T. Carey-Smith, S.N. Sparrow, D.A. Stone and S.M. Dean (2020) 'Climate change attribution and the economic costs of extreme weather events: a study on damages from extreme rainfall and drought', *Climatic Change*, https://doi.org/10.1007/s10584-020-02729-y

Haasnoot, M., J. Lawrence and A.K. Magnan (2021) 'Pathways to coastal retreat', *Science*, 372 (6548), pp.1287–90, doi:10.1126/science.abi6594

Hikuroa, D. (2020) 'Mātauranga Māori and its role in coastal management', in C. Hendtlass, S. Morgan and D. Neale (eds) (2020) *Coastal Systems and Sea Level Rise: what to look for in the future*, New Zealand Coastal Society, https://www.coastalsociety.org.nz/assets/Publications/Special-Issues/SP4-Low-res-version.pdf?

Iorns, C. (2022) 'Climate adaptation law reform: a lot of argument still to come', *Policy Quarterly*, 18 (1), pp.14–21

IPCC (2018) *Global Warming of 1.5°C: an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, IPCC

IPCC (2021) *Climate Change 2021: the physical science basis*, contribution of Working Group I to the sixth assessment report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press

IPCC (2022a) *Climate Change 2022: impacts, adaptation and vulnerability*, contribution of Working Group II to the sixth assessment report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press

IPCC (2022b) 'Climate change: a threat to human wellbeing and health of the planet: taking action now can secure our future', 28 February, https://www.ipcc.ch/2022/02/28/pr-wgii-ar6/

IPCC (2022c) *Climate Change 2022: impacts, adaptation and vulnerability: summary for policymakers*, Cambridge: Cambridge University Press

Kool, R., J. Lawrence, M. Drews and R. Bell (2020) 'Preparing for sea-level rise through adaptive managed retreat of a New Zealand stormwater and wastewater network', *Infrastructures*, 5 (11), doi:10.3390/infrastructures5110092

Lawrence, J., S. Allan and L. Clarke (2021) 'Inadequacy revealed and the transition to adaptation as risk management in New Zealand', *Frontiers in Climate*, 3

Lawrence, J., R. Bell and A. Stroombergen (2019) 'A hybrid process to address uncertainty and changing climate risk in coastal areas using dynamic adaptive pathways planning, multi-criteria decision analysis and real options analysis: a New Zealand application', *Sustainability*, 11 (406), doi:10.3390/su11020406

Lawrence, J., M. Haasnoot, L. McKim, D. Atapattu, G. Campbell and A. Stroombergen (2019) 'From theory to practice: a timeline of interventions by a change agent with the developers and users of dynamic adaptive policy pathways (DAPP)', in V. Marchau, W. Walker and P. Bloemen (eds), *Decision Making under Deep Uncertainty: from theory to practice*, Berlin: Springer

Lawrence, J., B. Mackey, F. Chiew, M.J. Costello, K. Hennessy, N. Lansbury, U.B. Nidumolu, et al. (2022a) 'Australasia', in IPCC, *Climate Change 2022: impacts, adaptation and vulnerability*, Cambridge: Cambridge University Press

Lawrence, J., B. Mackey, F. Chiew, M.J. Costello, K. Hennessy, N. Lansbury, U.B. Nidumolu, et al. (2022b) 'Australasia supplementary material', in IPCC, *Climate Change 2022: impacts, adaptation and vulnerability*, https://www.ipcc.ch/report/ar6/wg2/

Lawrence, J. and W. Saunders (2017) 'The planning nexus between disaster risk reduction and climate change adaptation', in I. Kelman, J. Mercer and J.C. Gaillard (eds), *The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation*, Routledge

Lawrence, J., S. Sullivan, A. Lash and G. Ide (2015) 'Adapting to changing climate risk by local government in New Zealand: institutional practice barriers and enablers', *Local Environment*, 20 (3), pp.298–320, doi:10.1080/13549839.2013.839643

Mechler, R. et al. (2022) 'Loss and damage', cross-chapter box in IPCC, *Climate Change 2022: impacts, adaptation and vulnerability*, Cambridge: Cambridge University Press

Milfont, T.L., E. Zubielevitch, P. Milojev and C.G. Sibley (2021) 'Ten-year panel data confirm generation gap but climate beliefs increase at similar rates across ages', *Nature Communcations*, 12 (1), doi:10.1038/s41467-021-24245-y

Ministry for the Environment (2017) *Coastal Hazards and Climate Change: guidance for local government*, Wellington: Ministry for the Environment

Ministry for the Environment (2019) *Arotakenga Huringa Āhuarangi: a framework for the national climate change risk assessment for Aotearoa New Zealand*, Wellington: Ministry for the Environment

Ministry for the Environment (2020) *National Climate Change Risk Assessment for Aotearoa New Zealand: main report – Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: pūrongo whakatōpū*, Wellington: Ministry for the Environment

New, M. et al. (2022) 'Decision making options for managing risk', in IPCC, *Climate Change 2022: impacts, adaptation and vulnerability*, Cambridge: Cambridge University Press

Paulik, R., S.A. Stephens, R.G. Bell, S. Wadhwa and B. Popovich (2020) 'National-scale built environment exposure to 100-year extreme sea levels and sea-level rise', *Sustainability*, 12 (4)

Resource Management Review Panel (2020) *New Directions for Resource Management in New Zealand: report of the Resource Management Review Panel*, Wellington: Resource Management Review Panel

Rouse, H.L., R.G. Bell, C.J. Lundquist, P.E. Blackett, D.M. Hicks and D-N. King (2017) 'Coastal adaptation to climate change in Aotearoa-New Zealand', *New Zealand Journal of Marine and Freshwater Research*, 51 (2), pp.183–222, doi:10.1080/00288330.2016.1185736

Salmon, G. (2019) 'Freshwater decline', *Policy Quarterly*, 15 (3), pp.8–16

Stephens, S.A., R.G. Bell and J. Lawrence (2018) 'Developing signals to trigger adaptation to sea-level rise', *Environmental Research Letters*, 13 (10), doi:10.1088/1748-9326/aadf96

United Nations Environment Programme (2020) *The State of the World's Forests 2020: forests, biodiversity and people*, UNEP

White, I. and J. Lawrence (2020) 'Continuity and change in national riskscapes: a New Zealand perspective on the challenges for climate governance theory and practice', *Cambridge Journal of Regions, Economy and Society*, 9, doi:10.1093/cjres/rsaa005