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Building New Zealand's Long-term Resilience to Hazards

Te Whakatipu i te Tū Pakari Tauroa o Aotearoa ki ngā Pūmate

Ministry for the Environment
Manatū Mō Te Taiao

DEPARTMENT OF THE PRIME MINISTER AND CABINET
TE TARI O TE PIRIMIA ME TE KOMITI MATUA

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Building New Zealand's long-term resilience to hazards

The Department of the Prime Minister and Cabinet and the Ministry for the Environment have developed this hazards-focused Long-term Insights Briefing on behalf of the National Hazards Board, to consider how New Zealand might better prepare to meet the challenges presented by future hazard events.

While Long-term Insights Briefings are not government policy, they are focused on the future, with the intention of supporting New Zealanders to consider and better plan for challenges we expect to face on the horizon. The content of this briefing is intended to spark thinking, conversation and, ultimately, action – by people, institutions and communities.

In this briefing we explore and share information on:

- New Zealand's evolving hazard landscape and how we can manage risks more proactively to protect people and assets
- the trade-offs and tough decisions New Zealand will need to make in building resilience, as well as the difficult realities we will need to understand
- opportunities for action, using case studies to illustrate potential ways we could strengthen resilience, leverage technology and develop innovative infrastructure.

Section 1: Understanding the hazard landscape

New Zealand's geological and geographical setting, historic patterns of development and economic profile mean hazards pose a significant challenge for our nation. New Zealand faces a high level of exposure to hazards – including earthquakes, volcanic activity, severe weather and flooding – and is consistently ranked among countries with elevated disaster risk due to this multi-hazard environment.[1] Further, mitigating the impacts of hazards, adapting to and recovering from them is increasingly difficult – as we grow and develop, we have more at stake and to manage, and the changing climate exacerbates existing risks. Recent crises like the global COVID-19 pandemic and severe weather events (such as the 2023 Auckland Anniversary Weekend floods and Cyclone Gabrielle) have highlighted many of the challenges: hazards are interconnected, global trends and events have domestic consequences, and the economic and social costs can be immense.

Since 2022, half of all New Zealanders have had their lives impacted by natural hazards, and just as many report feeling anxious or worried about storms and earthquakes and the impact they might have. Many people also feel underprepared for hazard events.[2]

To best protect our people, economy, environment and way of life, New Zealand must build resilience to hazards through a more proactive, whole-of-society approach.[i] This will require learning from the past, embracing new ideas and making some hard choices.

New Zealanders are familiar with cost-of-living pressures and housing affordability concerns. Building long-term resilience now is vital to prevent future, more serious economic disruptions and unmanageable costs that could make cost-of-living challenges even worse. **This Long-term Insights Briefing explores how New Zealand can enhance its long-term resilience to hazards.**

What is national resilience?

National resilience is the ability of a country to absorb, adapt to, recover from and transform through shocks and stresses. It is about being ready for hazards before they strike, responding effectively when they do and learning from each experience to build stronger systems and communities.

Resilience does not mean being immune to hazards. It means managing their impacts and adapting to a changing world to limit loss and harm. To do this well requires recognising how our economic, physical, social and environmental systems are connected. It also requires strong communities where individuals are informed and aware of how to prepare for and respond to a crisis.

However, resilience is more than a defensive necessity; it is also the foundation of long-term wellbeing and prosperity. Building resilience should be seen as a strategic opportunity – one that strengthens the economy, builds investment confidence and establishes a reputation that we are a country that builds and innovates and that cares for future generations. A resilient New Zealand is one where communities, councils and businesses can plan, invest and grow with greater certainty.

Deciding *not* to build resilience, or choosing to delay it, is a costly option. Avoiding upfront investment in resilience may be cheaper in the short term, but the long-term costs are far

[i] This means leveraging the collective knowledge, understanding and resources of all parts of the country.

greater.[ii] These include more expensive clean-ups and rebuilds in the wake of disasters, more loss of wealth and asset value, and lost business opportunities. Resilience is not a nice-to-have; it is a prudent way to ensure our prosperity and security.

New Zealand's major hazards

New Zealand's National Risk and Resilience Framework identifies the most significant potential crises, known as National Risks,[iii] that could have serious immediate and/or long-term effects on New Zealand's safety, prosperity and/or national security. The Framework ensures our National Risks are comprehensively considered and strategically planned for. These National Risks are outlined in the National Risk Register and require coordinated national action to build greater preparedness and resilience.[3]

Some of these National Risks have the potential to be catastrophic and some recurrent. While diverse in nature, these hazards share common consequences: they can severely impact human welfare, heavily damage New Zealand's critical infrastructure and impose high economic costs – particularly if they occur with little or no warning.

Pandemics

COVID-19 showed the scale of disruption a pandemic can cause. Future pandemics are likely to occur relatively frequently – potentially around once every 25 years for a less devastating strain or around once in 200 years for a highly infectious, highly virulent strain (COVID-19 was not considered to be one of these more devastating strains).[4] Modelling suggests that in these situations, the number of excess deaths – assuming no mitigations – range from 15,000–27,000 to 375,000–450,000.[5]

Earthquake

The Alpine Fault has a 75 per cent chance of rupturing in the next 50 years and an 80 per cent chance that the resulting earthquake will be at least a magnitude 8.[6] A large subduction earthquake on the southern Hikurangi Fault has a 26 per cent chance of occurring in the next 50 years,[7] while the Wellington Fault has an 11 per cent chance of rupturing in the Wellington–Hutt Valley segment in the next 100 years.[8] Each of these events could cause widespread damage to towns and cities, critical infrastructure and the economy.

Tsunami

Although New Zealand has not experienced a catastrophic tsunami in recent times, it is vulnerable to them, having occurred many times in the past – whether they are triggered by an earthquake here or on the other side of the Pacific. According to GNS, one scenario of a 1-in-500-year tsunami could lead to 33,000 fatalities, 27,000 injuries and $45 billion in property loss.[9]

[ii] According to the World Economic Forum, companies report that their current adaptation and resilience investments could yield between $2 and $19 for every $1 invested.

[iii] The National Risk Register includes 22 hazards which are governed and overseen by the National Hazards Board; additional National Risks, known as national security threats, are governed by the National Security Board.

Volcanic activity

Mount Taranaki has a 30 to 50 per cent chance of erupting in the next 50 years.[10] Auckland is built on top of a volcanic field, where it is almost certain there will be another eruption although it is unclear where or when this may be.[11] A plausible scenario for an eruption around Māngere Bridge could require hundreds of thousands of people to evacuate and lead to months- or years-long effects on critical infrastructure (including power and drinking water). There would also be long-term economic and land-use impacts that would challenge the longer-term recovery.[12]

Severe weather and flooding

Severe weather – including strong winds, heavy or prolonged rain or snow and coastal storm surges – can trigger flooding and landslides, posing serious risks to homes, workplaces and communities. Rising temperatures and shifting weather patterns are increasing the frequency and intensity of these events, with storms, floods and droughts becoming more common and more damaging.[13,14] These events already cost billions[15] and are expected to become even more economically disruptive as the climate continues to change.[16,17]

Severe space weather

Events such as solar storms can disrupt and damage critical technologies and infrastructure (such as power grids, satellites and communications systems) on Earth and in space. Potential impacts range from being without power for days to degraded communications and the loss of global positioning systems. Although historic impacts of space weather in New Zealand have been relatively rare, the probability of a severe event has increased since the sun entered a 'solar maximum'[iv] in October 2024.

[iv] Solar maximum is the period of highest activity during the sun's roughly 11-year solar cycle.

Section 2: Forces that shape risk and resilience

Where we live and what we rely on

New Zealand's position on the boundary of the Australian and Pacific tectonic plates makes it prone to hazards such as earthquakes, tsunami and volcanic activity.[18] Its long coastline, numerous rivers and high rainfall increase the risk of flooding, while its geographic isolation makes trade more challenging under disruptive conditions. Like all globally connected nations, New Zealand is also vulnerable to pandemics and other transboundary hazards.

New Zealand's economy lacks diversification, relying heavily on relatively few key agricultural exports and trading partners, especially in Asia.[19] This makes it more susceptible to external shocks such as falling global demand, drought, animal disease outbreak, or changes in trade policy.[20] Many farmers already operate under financial pressure, with low profit margins and high debt levels, making them particularly vulnerable to disruption.[21]

Climate change and environmental stress

Climate change and environmental stress amplify the impacts of natural hazards, increasing vulnerability across ecosystems, communities and key economic sectors. Rising temperatures and shifting weather patterns are intensifying the frequency and severity of storms, floods, droughts and wildfires. These changes are already causing significant disruption and are expected to become more economically damaging over time.

This amplifying effect also threatens biodiversity and ecosystems, including marine and coastal environments.[22] Wildfire risk is projected to rise significantly, with some regions potentially facing 'very extreme' conditions in future decades.[23] At the same time, biodiversity loss is increasing New Zealand's exposure to these hazards through the loss of natural buffers such as wetlands and native forests.

Key sectors like agriculture, forestry, fisheries and tourism – which are heavily reliant on climate-sensitive resources – face heightened vulnerability.[24] Rising adaptation costs will strain public finances, and sea level rise (potentially a metre higher by 2100) will challenge the two-thirds of New Zealanders living near the coast.[25]

Changing population and growing cities

New Zealand's population is increasing, older and more urban.[26] This will amplify our vulnerability to various hazards. Older people may face greater health risks and evacuation challenges during disasters.[27] Larger, denser cities can mean higher social and economic costs when hazards strike.[28] These trends compound existing vulnerabilities such as poverty, social isolation and inadequate housing.[29]

New technologies and digital systems

Advanced technologies are reshaping the global risk landscape, as they introduce new dependencies and vulnerabilities. Technologies such as artificial intelligence (AI), 5G mobile internet and autonomous systems affect every nation's resilience, because they are relied on for so much and because they are so hard to produce. This means there is significant

disruption when they fail and an over-reliance on the handful of companies who can make them.

Advanced semiconductor chips are an example. These chips serve as the 'brains' of most advanced technologies and are essential to everything from emergency services and power grids to communications and transport systems. However, due to the difficulty of making these chips, three companies dominate the supply chain: Nvidia (USA) designs them, ASML (Netherlands) builds the machines to create them and TSMC (Taiwan) uses those machines to manufacture them. This degree of concentration creates single points of failure: if the chain is disrupted – whether by geopolitical tension or natural disaster – the effects are felt worldwide, including in New Zealand.

Some wealthy nations are trying to build more resilient supply chains for these technologies through strategies such as increased domestic production, even where this is less efficient. Most other countries, including New Zealand, cannot afford this approach and are more likely to face challenges accessing critical technologies when supply chains are disrupted.

Global tensions and instability

New Zealand's resilience depends not only on physical infrastructure and supply chains, but also on the integrity of the information systems that support decision-making, public trust and global collaboration. However, geopolitical tensions and the increasing spread of misinformation and disinformation over digital platforms (amplified by AI) is placing mounting pressure on all these information systems. This trend will make global cooperation on transboundary hazards like pandemics harder, disrupt emergency responses and even endanger frontline workers during crises.[30]

Supply and trade risk

New Zealand's reliance on trade makes it vulnerable to supply chain shocks and major trade disruptions. Events like COVID-19, the war in Ukraine and the Suez Canal blockage have shown how quickly disruptions can cascade. In 2024, New Zealand ratified the Indo-Pacific Economic Framework Supply Chain Agreement to strengthen regional resilience. These efforts highlight the importance of international cooperation and shared standards.

When hazards combine and escalate

Severe weather, earthquakes and tsunami can set off other crises, such as pandemics, by displacing people, compromising sanitation and increasing human proximity to animals.[31] In addition, we often face multiple risks at the same time which can mean we experience their effects concurrently. For example, our changing climate increases the likelihood that we may face the impacts of severe weather and flooding while also experiencing other national risks such as earthquakes or national security threats (eg, cyberattacks on our information systems). New Zealand will continue to face concurrent risks spanning hazards as well as national security threats, putting pressure on our preparation efforts, response and recovery.

Section 3: Choices in building resilience

Living with hazards and their consequences will remain a fact of life. Unpredictable hazard events, finite resources and the importance of personal freedoms mean that eliminating all hazard risk is neither possible nor desirable. This section explores the trade-offs, constraints and shared responsibilities involved in strengthening resilience across our communities, economy and environment.

Understanding the trade-offs

Building resilience requires us to make tough decisions. Often this means choosing between two desirable outcomes, or accepting short-term costs for long-term gains. For example, we may need to trade efficiency for redundancy, or individual freedoms for collective safety. These are not easy choices, but they are necessary ones. The table below illustrates some of the high-level trade-offs that decision-makers may face when building resilience.

Table 1: Examples of potential resilience-building trade-offs

Deciding between	Potential outcome	Advantages	Trade-off
Efficiency and redundancy (spare capacity)	Use a mix of suppliers and store essential goods in different places.	Keeps goods and services flowing during disruptions.	Higher costs, especially for small and medium businesses.
Cost and robustness	Local and central government invest in infrastructure with a higher level of service.	Long-term reliability and savings.	High upfront costs and delayed benefits.
Future-proofing and phasing investment	Investing in more resilient infrastructure pre-crisis is cheaper and mitigates harm from hazards.	Avoids passing additional costs onto future generations – when mitigations will be more expensive.	Immediate costs, equity challenges.
Protecting the status quo and avoiding a sunk cost	Communities have robust infrastructure like seawalls and stop banks.	Fewer people are displaced from their homes and communities.	Might fail or cause amenities to lose value (eg, a new seawall spoils a beach).
Centralisation and decentralisation	Resources are targeted to community-level organisations to focus on resilience-building.	Community organisations have demonstrated they play a vital role in preparing for and responding to emergencies.	Smaller groups may not have the capacity to respond to a large-scale crisis.
Individual freedoms and collective resilience	Rules and regulations on land use in risky areas are strengthened.	Fewer people exposed to hazard, lower longer-term financial risk for individuals.	Can infringe on people's ability to live where they want, or where they have in the past.

What makes these decisions hard?

Resilience-building decisions are complicated by several factors, including:

- **differing risk appetites:** People, businesses, government and communities can all have different levels of risk tolerance, due to differing timelines or incentives
- **lack of data:** Information is not always accessible or available, to aid understanding of the full impacts of hazards[32]
- **opportunity cost:** Allocating funds, time and effort to resilience-building initiatives means shifting scarce resources away from other pursuits. This can make it difficult to build consensus, especially when the benefits of resilience may not be immediately visible.

These factors can make it challenging to agree on how best to enhance the resilience of shared assets like roads, rivers or apartment buildings. As a result, short-term interests can often win out over longer-term resilience efforts.[33] If New Zealand is to become a more resilient country, we must be willing to confront these trade-offs head on and make decisions that reflect our shared values and long-term goals.

Building a shared understanding of risk

Conceptualising risk is hard, especially when dealing with low-probability, high-impact events or cascading hazards.[34] However, recent history, from pandemics to cyclones, shows that events can and will likely occur multiple times within a single generation. Formal risk tolerance frameworks,[v] like those proposed by the Natural Hazards Commission, can help guide consistent, transparent decisions.[35] These frameworks, embedded in tools like the Natural Hazards Portal,[36] can support better conversations at national, regional, business and individual levels on acceptable levels of risk and who bears responsibility.

Who bears the risk?

Climate-related hazards are reshaping the insurance landscape. This trend is critically important for New Zealand, where property values are high and 57 per cent of our household wealth is tied up in residential property.[37]

Insurance companies are responding to increasing climate-related risk by raising premiums, limiting online quotes and withdrawing coverage in some areas altogether.[38] This insurance retreat is expected to continue. New Zealand homes and businesses are insured by international re-insurers who are facing increasing liabilities globally. As a small and higher risk insurance market, New Zealand has a strategic economic imperative to remain a viable and sustainable destination for reinsurance through proactive hazard management[39].

By 2050, at least 10,000 homes in main coastal centres may be uninsurable,[40] and even minor sea level rises could trigger partial insurance retreat for 99 per cent of homes in high-risk coastal zones by 2034.[41] If insurance becomes too expensive or unavailable, many New Zealand homeowners will face profound impacts on the value of their homes and their ability to secure mortgages.[42]

This raises a difficult question: who should bear the financial risk – individual homeowners or the Government on behalf of the wider community?

[v] A set of rules for deciding how much risk the business is willing to take.

- **Individual responsibility:** Homeowners choose where to live and should bear the consequences. This approach incentivises proactive risk reduction but can lead to social disruption and economic instability.
- **Government protection:** Public support can reduce hardship but may create moral hazard, blunt market signals and shift costs to taxpayers – including those not living in high-risk areas. It also raises serious questions about fairness and equity.

But the answer to who bears responsibility *need not be one or the other*. Finding the path forward may require a balance and a transition – incentivising individuals to be responsible through smarter pricing and planning rules, while also having strong government support and investment in community resilience.

Transparency and risk disclosure

Striking the right balance in hazard disclosure is challenging, but it is crucial to recognise that the risks and costs of climate change are real – and they exist whether we acknowledge them or not. Avoiding transparency, such as by withholding hazard information from property files, does not eliminate these risks; it simply delays effective responses and increases long-term costs. Clear understanding of property risks enables smarter, more cost-effective decisions that help communities adapt and reduce future impacts.

Section 4: Opportunities to build resilience

New Zealand's historical approach to managing hazards has often been reactive, with a reliance on insurance payouts and government funding to rebuild. This reactive model is not only expensive, it can perpetuate a dangerous cycle: when asset owners expect to be bailed out, they have less incentive to reduce their own risks.[43] This results in more New Zealanders remaining, building and investing in harm's way.

Enquiries and reports have pointed out that New Zealand is not well prepared for large hazards. When something major happens, such as a flood, earthquake or pandemic, the recovery is often ad hoc. This approach is costly and can cause delays and uncertainty, and added stress for communities, making it hard for people to plan.[44,45]

Taking a proactive approach is more cost-effective, saves lives and better protects homes, businesses and public assets. It also unlocks long-term benefits – from stronger communities and healthier ecosystems, to a more resilient and adaptable economy.[46]

There are a range of options that would allow New Zealand to build on existing resilience-enhancing efforts and create a more resilient future. This section explores how New Zealand could invest in a better understanding of hazards, prioritise efforts on the most consequential hazards, enhance community resilience, harness the opportunities of AI, invest in more resilient infrastructure and consider new approaches to better capture the full value of resilience.

What government is doing

New Zealand is already taking important steps toward a more resilient future. Recent government efforts reflect a growing recognition that resilience is central to economic security and wellbeing. The following initiatives are not just policy responses – they are economic enablers.

- The 2024 **National Risk and Resilience Framework**, approved by Cabinet, was developed to drive a more strategic and proactive approach to risk management across all of New Zealand's National Risks (hazards and national security threats).[47] This includes knowing what risks we face as a nation, what we are doing well and not well in managing them and taking steps to improve. The Framework aligns with the Government's focus on driving economic growth and protecting public safety by reducing New Zealand's vulnerability to the harm and cost of its National Risks while protecting New Zealand's safety and future prosperity.
- The **National Adaptation Plan**[48] and **Adaptation Framework**[49] help New Zealand adapt to the worsening impacts of climate change. The 2022 National Adaptation Plan outlines how New Zealand will respond to climate risks across infrastructure, communities, the economy and the environment. The Adaptation Framework, which is currently being developed, is intended to provide more clarity on the Government's approach to adaptation. The Adaptation Framework covers improvements to data and information, how costs may be shared, and roles and responsibilities – including for investment in risk reduction. Clarifying investment pathways will help to unlock private capital and guide infrastructure decisions.

- **New Zealand's Emergency Management System**[50] is undergoing significant improvements in response to the findings of the 2023 North Island Severe Weather Events Inquiry. These include reforms currently in progress, with legislative changes expected in 2025, alongside a government-endorsed investment and implementation roadmap. Together, these efforts aim to enhance the coordination, speed and effectiveness of emergency responses across the country.
- **The Resource Management Act** (RMA) has recently been amended to strengthen how New Zealand manages natural hazard risks through land-use planning. These legislative changes are being complemented by the development of a new **National Policy Statement for Natural Hazards** (NPS-NH), which is expected to come into force in late 2025. The NPS-NH will provide national direction to help councils make more robust, risk-based decisions about where development should occur and how it can be designed to better withstand natural hazards.
    - The NPS-NH is expected to serve as a building block for further improvements to how natural hazard risks are managed under the new resource management system, which will replace the RMA with new legislation in 2026. Notably, "adapting to the effects of climate change and reducing the risks from natural hazards" has been confirmed by Cabinet as a core objective of the wider resource management reform.
- **Pandemic preparedness**[51] efforts are underway, building on the lessons learned from the COVID-19 pandemic to improve surveillance, stockpiling, response coordination and public health infrastructure. This programme started in 2023, with phased implementation beginning in 2025.
- The **Natural Hazards Portal** provides property-level risk information and tools to support individual and community decision-making.[52]

Many other areas of government work also look to enhance New Zealand's resilience. To truly embed resilience, it is important to look beyond short-term political cycles. While governments naturally respond to immediate priorities, resilience-building benefits most from long-term thinking and continuity. Achieving lasting impact requires broad community commitment to strategies that can be sustained over decades. Embedding resilience into core government functions, investment planning and public engagement – regardless of who is in office – will help ensure that New Zealand is well prepared for future challenges and opportunities.

Taken together, this work generates valuable momentum for building a more resilient New Zealand. Sustaining these efforts and scaling them will be an important part of ensuring a safer and more prosperous future.

Community-led solutions

Community-led resilience

Resilience starts with people. Strong, connected communities – of individuals who know how to prepare and respond in a crisis – are a pillar of a resilient nation. Giving effect to a whole-of-society approach, where responsibility is shared by every individual, is essential. This can begin with simple steps, like making sure everyone understands the hazards we face and what actions they may need to take in a crisis. Effective resilience-building requires listening to voices across our communities and designing solutions that work for everyone. Māori, people living with disability and those in isolated communities may face unique risks. This means tailoring support to different needs and ensuring no one is left behind

Practical support and local empowerment

Experience shows that providing communities with readily accessible supplies and equipment at key locations can be valuable – for example, storing solar panels and satellite communications equipment in a sports club or marae so that an isolated community is not cut off. This kind of support can make more effective the kinds of support that New Zealanders already offer each other in a crisis. It could also prompt communities into developing actionable plans for how to prepare and respond to hazards.

These kinds of initiatives are low cost and high impact, and they can deliver immediate benefits. They demonstrate how focused planning, communication and community empowerment can help mitigate the impacts of hazards and build a stronger, more resilient New Zealand.

Learning from international models

New Zealand can also learn from international examples of all-of-society approaches. In response to growing security concerns, Sweden has revitalised its total defence concept – increasing budgets for civil and military preparedness, clarifying roles and responsibilities, and emphasising the importance of stockpiling essential supplies. Public awareness is central to this approach. Sweden has distributed a national brochure to every household, offering practical checklists and guidance on how to prepare for events like armed conflict or severe weather.[53] This communication reinforces the expectation that every citizen has a role to play in national resilience.

The United Kingdom's Strategic Defence Review echoes this approach[54]. It includes a two-year programme of public outreach to explain current threats, future trends and the role of society in national defence. It also highlights the importance of public–private cooperation to protect critical infrastructure and improve readiness – including through legislation and better use of reserve forces.

While these strategies reflect different national contexts, the core lesson is universal: public engagement is essential to national resilience. New Zealand could adopt a similar approach to those described above – distributing a national preparedness guide tailored to our unique hazard landscape and launching a public outreach campaign to build awareness and capability via relevant channels and platforms.

Using science, data and modelling

Understanding hazards and their effects

Understanding the hazards we face is the first step towards building resilience. Without a clear picture of the hazards we face, it is difficult to plan, prioritise, or act effectively. Science and data are essential to New Zealand better understanding how to prepare for and proactively manage hazards.

New Zealand has already made progress in this space. Tools like RiskScape,[55] future sea-level-rise maps and climate projections are helping to visualise and quantify risk. A major step forward is the Natural Hazards and Resilience Platform,[56] which brings together researchers, practitioners and communities to improve how we understand, manage and communicate natural hazard risks. The platform focuses on delivering science that is directly usable by decision-makers – from local councils to infrastructure providers – and supports a more integrated, systems-based approach to resilience.

However, making decisions in this space is rarely straightforward. Evidence is often lacking, inconclusive or inaccessible, especially when it comes to identifying which resilience measures will work best in different contexts. This uncertainty should not prevent action – but it does mean we need to monitor, learn and adapt as we go. Building resilience requires a mindset of continuous improvement, where decisions are informed by the best available data, but also flexible enough to evolve as new insights emerge.

Opportunities to improve understanding

To build on this foundation, New Zealand has several key opportunities – namely, to:

- make hazard risk data more accessible, through improved data-sharing platforms and agreements
- improve the quality and usability of data, by developing clear standards and consistent methods for data collection, generation and application
- grow technical expertise and risk-communication capability, including by integrating diverse knowledge systems – such as science and mātauranga Māori – and building the skills to translate complex data into actionable insights.

Realising these opportunities will require increased and sustained investment, but the payoff is significant: better decisions, more targeted investments and a stronger, more informed public.

Technology and AI

AI is rapidly emerging as a powerful tool in building resilience to hazards. AI is helping to shift hazard management from reactive to proactive, enabling smarter, faster and more inclusive approaches to risk anticipation, impact assessment and response planning.

Anticipating hazards

AI is transforming how to detect and anticipate hazard events, often before they escalate. These innovations are helping to move from reactive to proactive hazard management. Tools like QuakeFlow analyse seismic data to detect tiny tremors that traditional systems miss, offering early insights into fault stress and potential earthquake activity.[57] Smartphone-based earthquake alerts, such as Google's Android system use crowdsourced data to detect shaking and send out warnings within seconds.[58] AI also enhances tsunami forecasting by rapidly processing seismic and oceanographic data[59], and monitors volcanic activity by scanning satellite and ground data to detect subtle land movements that may signal an impending eruption.[60] In the health domain, AI supports early disease surveillance by analysing environmental and health data to detect early signs of outbreaks, supporting faster public health responses.[61,62]

Understanding impact

Before events occur, AI can assess factors like building age, construction quality, soil type and proximity to fault lines to identify high-risk areas and inform urban planning.[63] AI-powered climate projections enhance risk assessment by generating localized forecasts that help identify vulnerabilities and guide targeted resilience planning.[64]

After disasters, AI can analyse satellite imagery and drone data to rapidly assess damage to buildings and infrastructure, guiding emergency response. In search and rescue operations AI-

powered sound analysis can distinguish human calls for help from background noise, guiding rescue teams searching through rubble.[65]

Enabling people and systems

AI can also help to strengthen the systems and services that support hazard resilience.[66] Together, these applications help ensure that both people and systems are ready to respond effectively when hazards strike. Digital twins – virtual models of real-world environments like transport networks or urban areas – allow planners to simulate disaster scenarios, test resilience strategies and make informed decisions, as seen in earthquake response efforts in Türkiye[67] and flood-ready infrastructure in the United States.[68]

These tools can also support cross-agency planning and community engagement by visualising local risks and fostering collaborative decision-making. AI enhances this capability by translating complex hazard data into plain language, delivering tailored messages to diverse communities and improving access to trusted information through inclusive tools like chatbots and voice assistants.

These innovations align with the Public Service Commission's goals for digital transformation and smarter, user-centred public services.[69] As AI capabilities grow, New Zealand must consider how to harness these technologies across sectors to ensure readiness and resilience in the face of future hazards.

Designing more resilient infrastructure

Resilient infrastructure is critical to ensure people are safe, can access essential services and that the economy can handle disruptions.[vi] However, New Zealand faces a significant infrastructure deficit.[vii] If current trends continue, the shortfall is projected to reach $210 billion by 2050.[70] Addressing this infrastructure deficit in a fiscally responsible way will require innovation – not only in the types of infrastructure we build, but also in the frameworks we use to prioritise, evaluate and deliver investment.

This means embracing a full spectrum of resilience-building measures. These include using advanced materials, integrating technology to monitor infrastructure performance, rethinking how maintenance is planned and delivered, and designing systems that can be upgraded over time. Resilience must be built into infrastructure from the outset – not added as an afterthought. Two specific examples of resilient infrastructure are discussed below.

Nature-based solutions

One promising approach is the use of nature-based solutions – infrastructure that blends natural systems with green technology to reduce risk, restore ecosystems and strengthen community resilience. These solutions can be more cost-effective than traditional infrastructure, particularly in reducing flood risk, and often come with a range of co-benefits.[71]

Examples include engineered wetlands to manage stormwater, afforestation to stabilise landscapes, and urban features like green roofs and rain gardens. These approaches not only reduce hazard impacts but also improve biodiversity, air and water quality, and community wellbeing. In New Zealand, there is a unique opportunity to develop nature-based solutions

[vi] The New Zealand Infrastructure Commission is the Government's independent advisor on infrastructure. It released a draft National Infrastructure Plan that the Government will respond to in 2026.

[vii] The gap between the existing state of infrastructure and the level of infrastructure needed to adequately support the population, economy and public services.

informed by mātauranga Māori, ensuring they are well integrated into the landscape and deliver broader cultural and environmental benefits.[72]

Battery storage

A reliable electricity supply is critical to New Zealand's resilience. It powers essential services, supports economic activity and enables communities to function during crises. As climate-related disruptions become more frequent, targeted investment in energy infrastructure – particularly battery energy storage systems – offers a powerful way to strengthen resilience while delivering everyday benefits.

Battery storage systems can stabilise the grid, reduce energy costs and provide backup power during emergencies. A leading example is the Hornsdale Power Reserve in South Australia – the world's largest lithium-ion battery. Built in response to a state-wide blackout caused by severe weather, the battery has since delivered significant benefits. In its first two years of operation, it helped reduce power prices by an estimated AU$150 million and provided critical support when South Australia was temporarily disconnected from the national grid.[73]

New Zealand is beginning to follow suit. A large battery system recently opened in Ruakākā will enhance energy resilience in Northland – a region that has experienced repeated disruptions.[74] Additional measures are under investigation, including the potential for Northland to operate as an energy 'island' – running independently from local supply for up to three days if the national grid is compromised.

These investments demonstrate how energy resilience can be built into the system – not only to respond to emergencies, but to improve performance, reduce costs and support regional development every day.

Funding and investment strategies

Funding and investment strategies

New Zealand has finite national resources and always aims for its investments to provide the best return possible. One way to unlock greater value from resilience investment is to prioritise measures that reduce the impact of the most damaging potential hazards.

Although there is a broad consensus that proactive investment in resilience delivers positive outcomes, deciding where and how to invest for the greatest return is complex. Hazards are inherently uncertain – we do not always know where and when they will strike. Infrastructure systems are interconnected, and the costs of resilience are often shared across central and local government, the private sector and communities. These factors can make traditional cost-benefit analysis difficult to apply.[75]

In addition, balancing affordability and equity is critical. Careful consideration must be given to how the costs and benefits of resilience initiatives are distributed. This means weighing public and private benefits, to avoid placing disproportionate burdens on vulnerable communities or future generations. Achieving sustainable resilience requires a clear understanding of the long-term economic returns on investment, ensuring efforts are both impactful and financially viable across society.

New approaches to valuing resilience

To address this, new approaches are emerging that better capture the full value of resilience – including the intangible benefits like avoided disruption, social cohesion, long-term confidence, and avoiding potential maladaptation.[76] Examples of such approaches are described below.

- One approach is the **'triple dividend of resilience'**, which measures how resilience investments can deliver three types of benefit: avoiding losses, unlocking economic opportunities and delivering wider benefits.[77] This approach helps us see the value of acting early, even if a disaster does not happen right away. For example, building protection for a coastal town might not only safeguard homes, but also boost tourism and attract new investment by giving people more confidence in the area's future.[78]
- Other methods may include additional decision-support tools such as multi-criteria analysis or scenario planning and using more complex **tools like the New Zealand-developed MERIT** – a dynamic economics model that is designed to test the economic consequences of different resilience-building measures.[79]
- Australia has developed broad frameworks like the **'Enabling Resilience Investment Framework'**,[80] which can be used to create place-based risk mitigation options. Australia has also developed hazard-specific models. In addition, **Queensland's Economic Assessment Framework** of Flood Risk Management Projects was developed to compare and prioritise flood risk management projects.[81]

These tools highlight the opportunity for New Zealand to use existing knowledge and improved data to make smarter, more transparent investment decisions – and to ensure that resilience is not just a cost, but a catalyst for long-term value.

Section 5: Closing remarks

New Zealand faces growing challenges from hazards, but its resilience efforts are not starting from scratch. Across government, communities, iwi, businesses and science, momentum is building. We are developing better tools and information, smarter policies, and stronger partnerships. We are learning from past events and preparing for those yet to come.

However, national resilience is a long game. It requires sustained investment, strategic long-term thinking, working together, and the courage to make difficult decisions today for a safer and more prosperous tomorrow.

Enhancing our national resilience will help us mitigate the consequences of disasters, and capture an array of economic, social and environmental benefits. It will give our people and economy the opportunity to thrive – not just when conditions are easy, but also when they are hard.

Achieving a more resilient future will demand a broad approach. It will include investing in robust infrastructure that can withstand disruptions, fostering communities that are equipped to support one another, and harnessing the power of new technologies to help us anticipate and adapt to change.

But national resilience is not just about large-scale investments; it also demands that everyone plays their part. Every individual has a crucial role in national resilience, whether through assembling an emergency kit, knowing evacuation routes, participating in community preparedness planning, or making informed choices above where they live. When each of us contributes, we collectively build a better future for all.

References

[1] World Population Review. *Natural Disaster Risk by Country 2025*. Retrieved 28 July 2025.

[2] IAG. 2025. *New Zealand Wild Weather Tracker*. Auckland: IAG.

[3] Department of the Prime Minister and Cabinet. *New Zealand's National Risks*. Retrieved 7 July 2025.

[4] Aotearoa New Zealand Royal Commission of Inquiry into COVID-19 Lessons Learned. 2024. *COVID-19 Lessons Learned Main Report: Part 3 – Moving Forward*. p 170.

[5] Aotearoa New Zealand Royal Commission of Inquiry into COVID-19 Lessons Learned. 2024. *COVID-19 Lessons Learned Main Report: Part 3 – Moving Forward*. p 170.

[6] AF8 (Alpine Fault Magnitude 8). *What is AF8?*. Retrieved 7 July 2025.

[7] Pizer C, Clark K, Howarth J, Garrett E, Wang X, Rhoades D, Woodroffe S. 2021. Paleotsunamis on the Southern Hikurangi Subduction Zone, New Zealand, Show Regular Recurrence of Large Subduction Earthquakes. *The Seismic Record* 1(2): 75–84. https://doi.org/10.1785/0320210012

[8] Rhoades DA, Van Dissen RJ, Langridge RM, Little TA, Ninis D, Smith EGC, Robinson R. 2011. Re-evaluation of conditional probability of rupture of the Wellington–Hutt Valley segment of the Wellington Fault. *Bulletin of the New Zealand Society for Earthquake Engineering* 44(2), 77–86. https://doi.org/10.5459/bnzsee.44.2.77-86

[9] GNS Science. *Tsunami in New Zealand*. Retrieved 7 July 2025.

[10] Taranaki Emergency Management. *Volcanic Activity*. Retrieved 7 July 2025.

[11] Deligne NI, Fitzgerald RH, Blake DM, Davies AJ, Hayes JL, Stewart C, Wilson G, Wilson TM, Castelino R, Kennedy BM, Muspratt S, Woods R. 2017. Investigating the consequences of urban volcanism using a scenario approach I: Development and application of a hypothetical eruption in the Auckland Volcanic Field, New Zealand. *Journal of Volcanology and Geothermal Research* 336: 192–208. https://doi.org/10.1016/j.jvolgeores.2017.02.023

[12] Deligne NI, Fitzgerald RH, Blake DM, Davies AJ, Hayes JL, Stewart C, Wilson G, Wilson TM, Castelino R, Kennedy BM, Muspratt S, Woods R. 2017. Investigating the consequences of urban volcanism using a scenario approach I: Development and application of a hypothetical eruption in the Auckland Volcanic Field, New Zealand. *Journal of Volcanology and Geothermal Research* 336: 192–208. https://doi.org/10.1016/j.jvolgeores.2017.02.023; Blake DM, Deligne NI, Wilson TM, Lindsay JM, Woods R. 2017. Investigating the consequences of urban volcanism using a scenario approach II: Insights into transportation network damage and functionality. *Journal of Volcanology and Geothermal Research* 340: 92–116. https://doi.org/10.1016/j.jvolgeores.2017.04.010

[13] IPCC, 2023. *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. Geneva, Switzerland: IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647

[14] Victoria University of Wellington Chair in the Economics of Disasters and Climate Change. *Whakahura – extreme events and the emergence of climate change*. Retrieved 7 July 2025.

[15] Department of the Prime Minister and Cabinet, National Emergency Management Agency. 2023. *Proactive Release: Briefing to the Incoming Minister for Emergency Management and Recovery (NEMA)*.

[16] *UN News*. 2025. Real cost of disasters is 10 times higher than previously thought, says UN. 27 May.

[17] White A, Comendant C, Yee D, Moore D. 2025. *Natural hazards-related public spending in New Zealand*. Prepared for IAG by Sapere Research Group.

[18] National Institute of Water and Atmospheric Research. *Marine geological hazards*. Retrieved 7 July 2025.

[19] The Observatory of Economic Complexity. *New Zealand*. Retrieved 7 July 2025.

[20] Harvard Growth Lab, *Country and Product Complexity Rankings*. Retrieved 7 July 2025.

[21] Lu B. 2023. Developments in the agricultural sector. In: Reserve Bank of New Zealand. *November 2023 Financial Stability Report*. 26 October.

[22] Department of Conservation. 2020. *Biodiversity in Aotearoa: an overview of state, trends and pressures 2020*. Wellington: Department of Conservation.

[23] Melia N, Dean S, Pearce HG, Harrington L, Frame DJ, Strand T. 2022. Aotearoa New Zealand's 21st-Century Wildfire Climate. *Earth's Future* 10(6): e2022EF002853. https://doi.org/10.1029/2022EF002853

[24] Reserve Bank of New Zealand. 2021. *Climate Changed: 2021 and Beyond*. Wellington: Reserve Bank of New Zealand; The Treasury, Ministry for the Environment. 2023. *Ngā Kōrero Āhuarangi Me Te Ōhanga: Climate Economic and Fiscal Assessment 2023*. Wellington: The Treasury.

[25] National Institute of Water and Atmospheric Research. *Climate change and possible impacts for New Zealand*. Retrieved 7 July 2025.

[26] Population Reference Bureau. *Projected Population mid-2035 (millions)*. Retrieved 7 July 2025; Te Ara Ahunga Ora | Retirement Commission. *Older People*. Retrieved 7 July 2025; Worldometer. *New Zealand Population (Live)*. Retrieved 7 July 2025.

[27] Tuohy RJ. 2010. *Improving disaster preparedness of older adults living in the community*. GNS Science Report 2010/07. Institute of Geological and Nuclear Sciences Limited; Social Wellbeing Agency. 2023. *Older people experiencing vulnerability and multiple disadvantage in New Zealand: A report on the needs of older people (65+) in health, housing, finance, social connection, and access*. Wellington: Social Wellbeing Agency | Toi Hau Tāngata, Ministry of Social Development.

[28] Uitto JI. 1998. The geography of disaster vulnerability in megacities: A theoretical framework. *Applied Geography* 18(1): 7–16. https://doi.org/10.1016/S0143-6228(97)00041-6; Xu J, Wang Z, Shen F, Ouyand C, Tu Y. 2016. Natural disasters and social conflict: A systematic literature review. *International Journal of Disaster Risk Reduction* 17: 38–48. https://doi.org/10.1016/j.ijdrr.2016.04.001

[29] Environmental Health Intelligence New Zealand. 2024. *Social vulnerability to the impacts of climate-related hazards in Aotearoa New Zealand*. Prepared for He Pou a Rangi Climate Change Commission by Environmental Health Intelligence New Zealand, Massey University.

[30] European Commission. *Information manipulation and misinformation. A threat for EU civil protection and humanitarian aid*. Retrieved 7 July 2025.

[31] United Nations Office for Disaster Risk Reduction. 2017. *Words into Action Guidelines: National Disaster Risk Assessment. Governance System, Methodologies and Use of Results*; Organisation for Economic Co-operation and Development. 2022. *The Impact of Natural Hazards on Hazardous Installations*.

[32] Noy I. 2025. NZ has no dedicated database to track losses from weather disasters – without it, we're planning in the dark. *The Conversation*. 18 March.

[33] New Zealand Government. 2024. *Environment Committee Inquiry into Climate Adaptation: Summary of Submissions*. Wellington: New Zealand Government.

[34] Office of the Prime Minister's Chief Science Advisor. 2016. *Making decisions in the face of uncertainty: Understanding Risk, Part 1, May 2016*. Auckland: Office of the Prime Minister's Chief Science Advisor.

[35] Natural Hazards Commission | Toka Tū Ake. *Risk tolerance methodology*. Retrieved 7 July 2025.

[36] Natural Hazards Commission | Toka Tū Ake. Natural *Hazards Portal: Natural hazards in your area*. Retrieved 7 July 2025.

[37] Nicholls K, Yankanna A, Nguyen C, Wild D. 2024. General Insurance Industry Stress Test Results. *Reserve Bank of New Zealand Bulletin* 88(2): 1–25; Carvalho PA, Baker B, Farquharson A. 2022. *Housing as an Investment Asset in New Zealand: Looking at risk-adjusted portfolio choices*. Reserve Bank of New Zealand Analytical Note Series. Wellington: Reserve Bank of New Zealand.

[38] Newton K. 2024.Treasury data shows insurers honing in on flood-risk properties. *RNZ* 24 July; Insurance Council of New Zealand. 2025. *Annual Review 2024*.

[39] Ministry for the Environment. 2025. A proposed approach for New Zealand's adaptation framework. Wellington: Ministry for the Environment.

[40] Storey B, Owen S, Noy I, Zammit C. 2020. *Insurance Retreat: Sea level rise and the withdrawal of residential insurance in Aotearoa New Zealand*. Prepared for the Ministry of Business, Innovation and Employment through the Deep South National Science Challenge.

[41] Storey B, Owen S, Zammit C, Noy, I. 2024. Insurance retreat in residential properties from future sea level rise in Aotearoa New Zealand. *Climatic Change* 177: 44. https://doi.org/10.1007/s10584-024-03699-1

[42] Storey B, Owen S, Noy I, Zammit C. 2020. *Insurance Retreat: Sea level rise and the withdrawal of residential insurance in Aotearoa New Zealand*. Prepared for the Ministry of Business, Innovation and Employment through the Deep South National Science Challenge; de Pont O, Wong C. 2023. The future of insurance cover for weather-related natural disasters. In: MinterEllisionRuddWatts *Cover to Cover* Issue 29. pp 17–19.

[43] HM Treasury. 2020. *Government as insurer of last resort: managing contingent liabilities in the public sector*. United Kingdom: HM Treasury.

[44] Including but not limited to: 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; Ministry of Civil Defence. 2017. *Ministerial Review: Better Responses to Natural Disasters and Other Emergencies in New Zealand*. Wellington: Department of the Prime Minister and Cabinet; Ministerial Inquiry into Land Uses in Tairawhiti and Wairoa. 2023. *Outrage to optimism: Report of the Ministerial Inquiry into land uses associated with the mobilisation of woody debris (including forestry slash) and sediment in Tairawhiti/Gisborne District and Wairoa District*. Wellington: Ministry for the Environment; Bush International Consulting. 2023. *Auckland flood response review: Independent, external review of events, January 27–29, 2023*. Auckland: Auckland Council; Bush International Consulting. 2024. *Hawke's Bay Civil Defence and Emergency Management Group Response to Cyclone Gabrielle*. Hawke's Bay: Hawke's Bay Emergency Management; Royal Commission of Inquiry into COVID-19 Lessons Learned. 2024. *COVID-19 Lessons Learned Main Report*. Wellington: Royal Commission of Inquiry into COVID-19 Lessons Learned; Review into the Future for Local Government. 2023. *He piki tūranga, he piki kōtuku – The future for local government*. Wellington: Department of Internal Affairs; National Emergency Management Agency. 2024. *2023 North Island Severe Weather Events: NEMA's Internal Operational Lessons Report*. Wellington: National Emergency Management Agency.

[45] Insurance Council of New Zealand. *Cost of natural disasters*. Retrieved 7 July 2025.

[46] Sharifi A. 2021. Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review. *Science of the Total Environment* 750: 141642. https://doi.org/10.1016/j.scitotenv.2020.141642

[47] For more information, see Department of the Prime Minister and Cabinet. *National Risk and Resilience Framework*. Retrieved 7 July 2025.

[48] For more information, see Ministry for the Environment. 2022. *Aotearoa New Zealand's first national adaptation plan.* Wellington: Ministry for the Environment.

[49] For more information, see Ministry for the Environment. *Adaptation framework*. Retrieved 7 July 2025.

[50] For more information, see Department of the Prime Minister and Cabinet. 2024. *Strengthening disaster resilience and emergency management*. Wellington: Department of the Prime Minister and Cabinet.

[51] For more information, see Ministry of Health. 2024. *New Zealand Pandemic Plan: A framework for action*. Wellington: Ministry of Health.

[52] Natural Hazards Commission | Toka Tū Ake. *Natural Hazards Portal: Home*. Retrieved 7 July 2025.

[53] The Swedish Civil Contingencies Agency. 2024. *In Case of Crisis and War*. Sweden: MSB.

[54] United Kingdom Ministry of Defence. 2025. *Strategic Defence Review, Making Britain Safer: secure at home, strong abroad*. United Kingdom: Ministry of Defence.

[55] National Institute of Water and Atmospheric Research, Institute of Geological and Nuclear Sciences Ltd. *RiskScape*. Retrieved 7 July 2025.

[56] GNS Science. *Natural Hazards and Resilience Platform*. Retrieved 7 July 2025.

[57] *Reuters*. 2025. AI is shaking up the hidden world of earthquake forecasting. 1 April

[58] Google Crisis Response. *Android early earthquake warnings*. Retrieved 7 July 2025.

[59] Innoreports. Science & Tech. 2023. *AI-Powered Tsunami Early Warning System Enhances Safety*. Retrieved 7 July 2025.

[60] Liu X, Zhang Y, Shan X, Wang Z, Gong W, Zhang G. 2025. Deep Learning for Automatic Detection of Volcanic and Earthquake-Related InSAR Deformation. *Remote Sensing* 17(4): 686. https://doi.org/10.3390/rs17040686

[61] Suvvari TK, Kandi V. 2024. Artificial intelligence enhanced infectious disease surveillance - A call for global collaboration. *New Microbes and New Infections* 62: 101494. https://doi.org/10.3390/buildings14103255

[62] MacIntyre CR, Limitation S, Quigley A. 2022. Preventing the next pandemic: Use of artificial intelligence for epidemic monitoring and alerts. *Cell Reports Medicine* 3(12): 100867. https://doi.org/10.1016/j.xcrm.2022.100867

[63] Estêvão JMC. 2024. Effectiveness of Generative AI for Post-Earthquake Damage Assessment. *Buildings* 14(10): 3255. https://doi.org/10.3390/buildings14103255

[64] National Institute of Water and Atmospheric Research. *High-resolution climate projections using physics and AI*. Retrieved 7 July 2025; Riedel K. 2024. *Impact-based forecasts and warnings*. Prepared for the Ministry of Business, Innovation, and Employment by NIWA through the Resilience to Nature's Challenges – Kia manawaroa – Ngā Ākina o Te Ao Tūroa National Science Challenge.

[65] Premachandra C, Kunisada Y. 2023. GAN Based Audio Noise Suppression for Victim Detection at Disaster Sites With UAV. *IEEE Transactions on Services Computing* 17(1): 183–193. http://dx.doi.org/10.1109/TSC.2023.3338488

[66] Ministry of Business, Innovation & Employment. 2025. *New Zealand's AI Strategy: Investing with confidence*. Retrieved 8 July 2025.

[67] Korkmaz M, Zulfikar AC, Demirkesen S. 2024. Leveraging Digital Twins as a Common Operating Picture for Disaster Management: Case of Seismic Hazards. *International Journal of Geo-Information* 13(12): 430. https://doi.org/10.3390/ijgi13120430

[68] Razavi H, Titidezh O, Asgary A, Bonakdari H. 2024. Building Resilient Smart Cities: The Role of Digital Twins and Generative AI in Disaster Management Strategy. In: S Pourroostaei Ardakani, A Cheshmehzangi (eds) *Digital Twin Computing for Urban Intelligence*. Urban Sustainability. Singapore: Springer. pp 95–118. https://doi.org/10.1007/978-981-97-8483-7_5

[69] Digital.Govt.NZ. *Public Service AI framework*. Retrieved 8 July 2025.

[70] Hon Chris Bishop. 2025. Speech to NZ Infrastructure Investment Summit. *Beehive.govt.nz* 13 March.

[71] Griffiths J, Semadeni-Davies A, Borne K, Tanner C. 2024. *Nature-based solutions for flood management: Literature Review*. NIWA report prepared for Envirolink. Christchurch: Envirolink.

[72] Boffa Miskell Ltd. 2024. *Nature-based Solutions for Climate Adaptation: Roadmap for scaling use in Aotearoa New Zealand*. Prepared for the Ministry for the Environment by Boffa Miskell Ltd.

[73] Aurecon. *Hornsdale Power Reserve.* Retrieved 7 July 2025.

[74] Meridian Energy. *Completion of Ruakākā Battery Energy Storage System*. Retrieved 7 July 2025.

[75] Wise RM, Capon T, Lin BB, Stafford-Smith M. 2022. Pragmatic cost-benefit analysis for infrastructure resilience. *Nature Climate Change* 12: 881–883. https://doi.org/10.1038/s41558-022-01468-5

[76] Wise RM, Capon T, Lin BB, Stafford-Smith M. 2022. Pragmatic cost-benefit analysis for infrastructure resilience. *Nature Climate Change* 12: 881–883. https://doi.org/10.1038/s41558-022-01468-5

[77] Tanner T, Reid RCJ, Wilkinson E, Rajput S, Surminski S, Maruyama Rentschler JE. 2018. *The triple dividend of resilience: realizing development goals through the multiple benefits of disaster risk management (English)*. Washington, DC: World Bank Group.

[78] Rözer V, Surminski S, Laurien F, McQuistan C, Mechler R. 2023. Multiple resilience dividends at the community level: A comparative study of disaster risk reduction interventions in different countries. *Climate Risk Management* 40: 100518. https://doi.org/10.1016/j.crm.2023.100518

[79] McDonald N, Timar L, McDonald G, Murray C. 2020. Better resilience evaluation: Reflections on investments in seismic resilience for infrastructure. *Bulletin of the New Zealand Society for Earthquake Engineering* 53(4): 203–214. https://doi.org/10.5459/bnzsee.53.4.203-214

[80] Wise R, Marinopoulos J, O'Connell D, Mesic N, Tieman G, Gorddard R, Chan J, Flett D, Lee A, Box P, Meharg S, Helfgott A. 2022. Guidance for applying the Enabling Resilience Investment Framework: Building national capability for Enabling Resilience Investment. Australia: CSIRO. https://doi.org/10.25919/vkh4-mh60

[81] State of Queensland (Queensland Reconstruction Authority). 2021. *Economic Assessment Framework of Flood Risk Mitigation Projects.* Queensland: Queensland Reconstruction Authority.