






# Investing in Early Warning Capability for Floods and Storms

An Appraisal of Benefits and Costs for New Zealand

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## Contents

<b>Authors</b>	<b>8</b>
<b>Acknowledgements</b>	<b>8</b>
<b>Executive Summary</b>	<b>9</b>
Summary	9
Background	10
Approach and Findings	14
<b>1. Background</b>	<b>23</b>
<b>2. Policy Appraisal</b>	<b>25</b>
<b>3. Benefits</b>	<b>27</b>
3.1. Market Costs Averted	30
3.2. Fiscal Costs Averted	31
3.3. Wellbeing Costs Averted	32
3.4. Further Costs Averted: Environmental and Cultural Capital, and Wider Non-Quantified Impacts	35
3.5. Benefits of EWC: Estimation Reductions in Flood and Storm Events	37
<b>4. Public Costs</b>	<b>39</b>
<b>5. Different Climate Change Scenarios</b>	<b>40</b>
<b>6. Results</b>	<b>41</b>
6.1. Base Case Appraisal	41
6.2. Different Climate Change Scenarios	43
6.3. Sensitivity Analyses	43
<b>7. Discussion and Limitations</b>	<b>47</b>
<b>References</b>	<b>50</b>

<b>Appendix</b>	<b>55</b>
Alternative Calculations for Wider Societal and Wellbeing Costs	57

## List of Tables

Table 1: Estimated Past Average Annual Costs for Regional AEP 1% Floods and Storms Across Scenarios (NZ\$ Million, 2026 Price Year)	19
Table 2: Estimated Past Average Annual Costs of AEP 1% Floods and Storms Across Scenarios (NZ\$ Million, 2026 Price Year)	29
Table 3: Estimated Reductions in Average Annual Flood and Storm Costs (NZ\$ Million, 2026 Price Year)	39
Table 4: Social Cost-Benefit Analysis – Base Case Appraisal (NZ\$, 2026 Price Year)	42
Table 5: Sensitivity Analysis – Varying Estimated Reductions in Flood Costs (NZ\$ Billion, 2026 Price Year)	45
Table 6: Gabrielle+ (List of Selected Events Included in Wider Scenario)	55

## List of Figures

Figure 1: Central Government Appropriated Spend on Natural Hazards by the 4Rs, Including Net Claims Costs from EQC and Southern Response	12
Figure 2: Risk = Hazard x Exposure x Vulnerability	13
Figure 3: Base Case Appraisal – Costs and Benefits	15
Figure 4: Tangible and Intangible Impacts Associated With Flood and Storm Events	28

## Abbreviations

4Rs	Risk Reduction, Readiness, Response, and Recovery
AEP	Annual Exceedance Probability
BCR	Benefit-Cost Ratio
CBAx	Cost-Benefit Analysis (extended)
CRED	Centre for Research on the Epidemiology of Disasters
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DPMC	Department of the Prime Minister and Cabinet
EM-DAT	Emergency Events Database
EMS-OS	Emergency Management System – Operating System
EQC	Earthquake Commission
EWC	Early Warning Capability
EWS	Early Warning System
ICNZ	Insurance Council of New Zealand
IFRC	International Federation of Red Cross and Red Crescent Societies
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
MAR	Monitoring, Alerting, and Reporting
MfE	Ministry for the Environment
NEMA	National Emergency Management Agency
NHC	Natural Hazards Commission
NISWE	North Island Severe Weather Events
NIWA	National Institute of Water and Atmospheric Research
NPSV	Net Present Social Value
NZIER	New Zealand Institute of Economic Research
OECD	Organisation for Economic Co-operation and Development
ROI	Return on Investment
UNDRR	United Nations Office for Disaster Risk Reduction

UNESCO	United Nations Educational, Scientific and Cultural Organization
WELLBY	Wellbeing-Year
WTP	Willingness to Pay

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## Executive Summary

### Summary

Severe weather events causing flooding are increasingly affecting New Zealand, generating significant economic losses and undermining wellbeing. Recent emergencies highlight a growing trend: flood and storm events are becoming both more frequent and more severe, placing escalating pressure on public infrastructure, communities, and government resources.

Historical analysis estimates that major flood and storm events with 1% AEP<sup>1</sup> have imposed average annual social costs of around NZ\$ 1.5 billion (of which NZ\$ 0.7 billion have our highest confidence), equivalent to about NZ\$ 47 billion if extrapolated forwards over a 50-year period (discounted).<sup>2</sup> Without intervention, these impacts are expected to intensify as climate change increases hazard exposure and vulnerability. Currently, around 15% of New Zealand's population (about 750,000 people) is exposed to flooding risk.<sup>3</sup> Projections indicate this number could rise to more than 900,000 people in the coming decades, significantly increasing the potential social and economic consequences of future events.

Proactive investment in risk-reduction technologies presents a strong economic and resilience opportunity. Our modelling of 1% AEP events indicates that targeted investment could avert around NZ\$ 4.4 billion in flood-related damages over a 50-year period (discounted). Achieving this outcome would require a relatively modest annual investment of about NZ\$ 28 million in the mid to long-term, delivering an estimated benefit-cost ratio (BCR) of 4.9. Even under a conservative scenario that includes only market impacts supported by the highest-confidence evidence, the investment continues to demonstrate

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<sup>1</sup> In the context of natural disasters and risk management, 'AEP' stands for 'Annual Exceedance Probability'. It is a statistical term used to describe the likelihood or probability of a natural hazard event (such as a flood, storm surge, or rainfall event) of a certain size occurring in any given year. AEP is expressed as a percentage. A 1% AEP event means there is a 1% chance (a 1-in-100 chance) of that event being equalled or exceeded in any single year.

<sup>2</sup> All flood and storm events with an AEP of 0.5% up to 1.49%. This includes the Auckland Anniversary Weekend floods of 2023 and excludes Cyclone Gabrielle (with an AEP of 0.45%). A scenario including Cyclone Gabrielle and other, wider events is explored in a sensitivity analysis.

<sup>3</sup> National Institute of Water and Atmospheric Research. (2025). Flood hazard across Aotearoa New Zealand [Dashboard]. ArcGIS.

<https://niwa.maps.arcgis.com/apps/dashboards/8c1db2b8e37841f29a57a38675388897>

strong value for money, with a BCR of 2.4. Early action represents a cost-effective pathway to reduce long-term fiscal risk, protect communities, and strengthen national resilience. Strategic investment now can shift New Zealand's approach from reactive disaster recovery toward proactive risk management, delivering substantial economic and societal benefits over time.

## Background

Building New Zealand's long-term resilience to hazards, such as severe weather, tsunamis, pandemics, volcanic activity, and earthquakes, has been an increasing focus for policy-makers as evidenced by recent reports by the Department of Prime Minister and Cabinet (DPMC), Ministry for the Environment (MfE)<sup>4</sup>, the New Zealand Treasury<sup>5</sup>, and the National Infrastructure Commission<sup>6</sup>. As the joint briefing by DPMC and MfE states, "Resilience is not a nice-to-have; it is a prudent way to ensure our prosperity and security".

New Zealand's National Risk and Resilience Framework<sup>7</sup> identifies the most significant potential crises, known as National Risks, that could have serious immediate and/or long-term effects on New Zealand's safety, prosperity and/or national security. Severe weather and flooding are identified as one of the six major hazards that are either catastrophic in their potential or occur so frequently that they produce significant cumulative impacts on human welfare, especially if they occur with little or no warning.

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

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<sup>4</sup> Department of the Prime Minister and Cabinet & Ministry for the Environment. (2025). *Building New Zealand's long-term resilience to hazards: Long-term insights briefing*. New Zealand Government.

<https://www.dPMC.govt.nz/sites/default/files/2025-08/ltib-draft-building-new-zealands-long-term-resilience-hazards.pdf>

<sup>5</sup> New Zealand Treasury. (2025). *Te Ara MokoPuna: Treasury's 2025 long-term insights briefing – Sustainable and resilient fiscal policy through economic shocks and cycles*.

<https://www.treasury.govt.nz/sites/default/files/2025-08/te-ara-mokopuna-ltib-2025.pdf>

<sup>6</sup> New Zealand Infrastructure Commission / Te Waihangā. (2026). *National infrastructure plan: Mahere Tūāhanga ā-Motu*. <https://media.umbraco.io/te-waihangā-30-year-strategy/zsunlry/national-infrastructure-plan-03032026.pdf>

<sup>7</sup> Department of the Prime Minister and Cabinet. (2024). *National risk and resilience framework*. New Zealand Government. <https://www.dPMC.govt.nz/our-programmes/risk-and-resilience/national-risk-and-resilience-framework>

common and damaging.<sup>8</sup> These events already cost billions<sup>9</sup> and are expected to become even more economically as well as socially, psychologically, and environmentally disruptive as the climate continues to change.<sup>10</sup>

Investing in risk reduction is, in the long run, far more cost effective than payment for damage-repair or replacement after a disaster has occurred. While a response capability to an emergency event remains essential, reducing risk and improving New Zealand's readiness to these events enables hazards to be anticipated earlier and impact to be mitigated before they escalate, lowering the human and economic costs of disasters. Recent New Zealand research shows that, across the four domains of emergency management – risk reduction, readiness, response, and recovery (the 4Rs) – natural hazard spending over the last 15 years has been disproportionately concentrated on the reactive domains of response and recovery, rather than on proactive investment in risk reduction and readiness.<sup>11</sup>

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<sup>8</sup> Intergovernmental Panel on Climate Change. (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. IPCC. [https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC\\_AR6\\_SYR\\_LongerReport.pdf](https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf)

Te Herenga Waka – Victoria University of Wellington, Chair in the Economics of Disasters and Climate Change. (2024). Whakahura – Extreme events and the emergence of climate change: A synthesis. <https://www.wgtn.ac.nz/cedcc/research/whakahura>

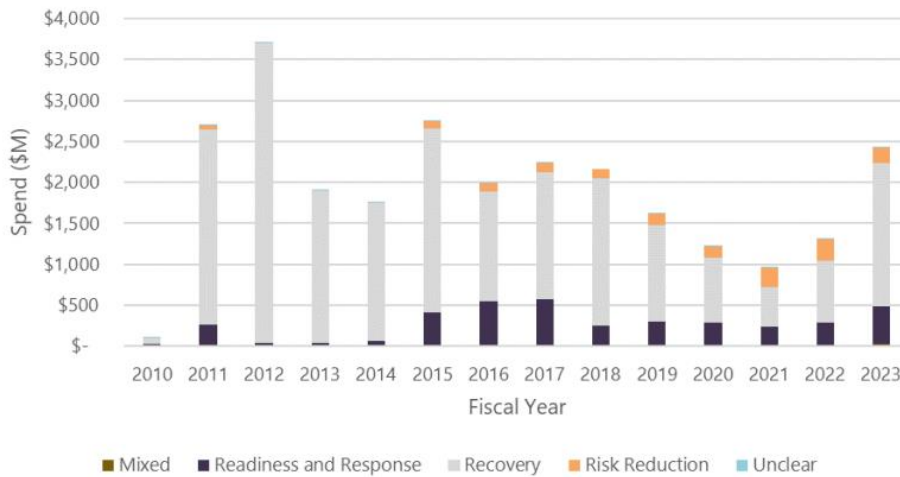
<sup>9</sup> National Emergency Management Agency. (2023). Briefing to the incoming Minister for Emergency Management and Recovery. Department of the Prime Minister and Cabinet. <https://www.dpmc.govt.nz/sites/default/files/2024-02/bim-2023-nema.pdf>

<sup>10</sup> United Nations Office for Disaster Risk Reduction. (2025). *Global assessment report on disaster risk reduction 2025: Resilience pays – Financing and investing for our future*. UNDRR. <https://www.undrr.org/gar/gar2025>  
Sapere Research Group. (2025). *Natural hazards-related public spending in New Zealand: Tracking costs over time by the nature of spending* (commissioned by IAG New Zealand). <https://www.iag.co.nz/content/dam/corporate-iag/iag-nz/nz/en/documents/corporate/natural-hazards-public-spending-nz-final.pdf>

Quoted in DPMC and MfE (2025), *ibid*, p. 9.

<sup>11</sup> Sapere Research Group. (2025). *Natural hazards-related public spending in New Zealand: Tracking costs over time by the nature of spending* (commissioned by IAG New Zealand). <https://www.iag.co.nz/content/dam/corporate-iag/iag-nz/nz/en/documents/corporate/natural-hazards-public-spending-nz-final.pdf>

**Figure 1: Central Government Appropriated Spend on Natural Hazards by the 4Rs, Including Net Claims Costs from EQC and Southern Response**



Note: EQC and Southern Response financial reports for the years 2024 and 2025 were not complete at the time of writing this report, and thus are not included in this graph.

Source: Sapere Research Group (2025).

This report presents a value-for-money analysis to support the case for investment in enhancing New Zealand’s Early Warning Capability (EWC) to detect and issue alerts for risks emanating from threats of natural hazards. EWC refers to the specific desired effect under specific conditions through a combination of systems, processes, people and technologies required to detect emerging natural hazards, interpret risk, and communicate timely warnings that enable proactive action before an impact occurs or escalates.

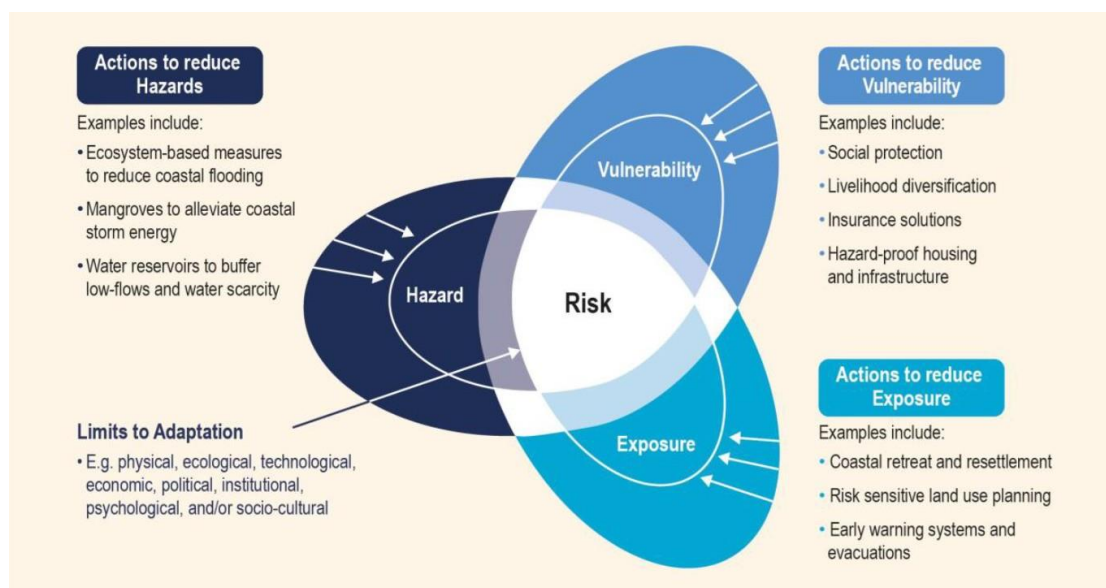
The analysis in this report focuses primarily on the role of technology within Early Warning Systems (EWS), a component of an EWC. The benefits that an investment in such a technology can deliver represents a proactive measure to improve outcomes from flooding caused by severe weather events. While this focus allows for a more robust and tractable analysis, it represents only one component of a broader set of capabilities that are required to reduce the impact from a disaster.

EWS rely on the timely availability of hazard intelligence, shared situational awareness, and coordinated decision-making to translate warnings into effective action. As a result, the benefits estimated in this report are likely to underestimate the wider potential value of technology investments that strengthen the broader systems and capabilities required to anticipate, understand, and respond to hazards. These benefits can extend across economic, psychosocial, environmental and cultural domains.

In the base case appraisal, proactive investment in EWC, enabling early warnings for flooding and storm events, can provide a BCR of 4.9, indicating that the expected benefits outweigh the costs by a factor of almost five. That is, even under conservative assumptions and modelling where only flood and storm impacts are experienced, the investment produces almost five dollars in benefit for every dollar invested.

Any other benefits of the EWS attributable to other threats, such as volcanic eruptions or tsunamis, would be additional.<sup>12</sup>

**Figure 2: Risk = Hazard x Exposure x Vulnerability**



Source: IPCC (2019).

Given New Zealand's inherent vulnerability to natural hazards, the ability to anticipate and prepare for emergencies is of critical importance. EWC serves as one vital proactive aspect in this context, aiming to lessen the destructive power of emergencies by providing timely and relevant information that empowers individuals, communities, and organisations to take

<sup>12</sup> Effectively reducing impacts for these wider hazards would require further, marginal investment in, for example, certain modelling capabilities. This would provide further, marginal benefits. The current modelling only illustrates the costs of the EWS focussed on flood and storm events and the benefits for flood and storm events (a subset of potential benefits).

appropriate actions in advance of an impending hazard. This capability is not simply about predicting when and where an emergency might take place; its true value lies in its capacity to trigger timely and effective responses that minimise potential harm and loss.

LSE Consulting has been commissioned by NEMA to appraise the value for money for proactive investment in technology to equip people with the right technologies to improve EWC for New Zealand. Investment in technology supporting an EWS is one of several investments, extending beyond EWC, that NEMA is collaborating on with various government agencies to improve New Zealand's resilience to natural disasters.

## Approach and Findings

### Base Case Appraisal

The key result from our base case<sup>13</sup> social cost-benefit analysis is a net present social value (NPSV) of NZ\$ 3.5 billion over 50 years and a benefit-cost ratio (BCR) and return-on-investment (ROI) of 4.9, indicating that proactive investment for the establishment of EWC to support the 4Rs where floods and storms create substantial social value and that its expected benefits exceed its costs by a factor of almost five. Even when we only include market benefits with higher confidence<sup>14</sup>, the benefits are more than double the costs (BCR of 2.4). This may be conservative: there may be even further benefits, currently non-monetised, where the EWC could also improve responses for other threats such as tsunami or volcanic activity.

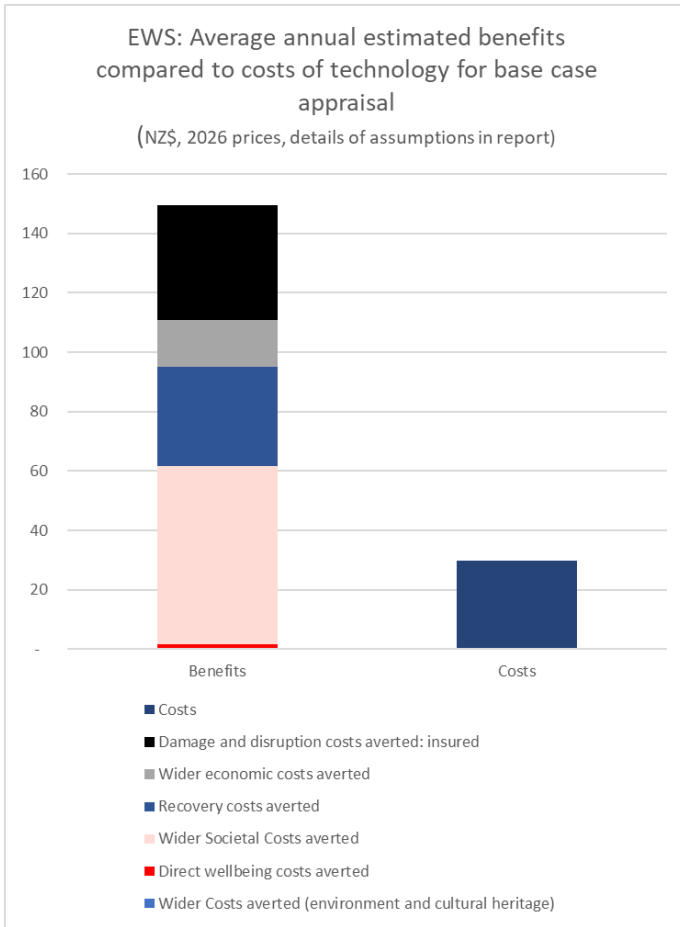
The key uncertainty is the extent that the EWC reduces potential impacts. Based on international evidence, this report includes a range of 5% up to 30% reduction, with a reduction of 10% for the base case. However, the technology would only have to reduce average impacts of major flood and storm events by 2% for the technology to be value for money.

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<sup>13</sup>The base case includes a time horizon of 50 years, a discount rate of 2%, current climate conditions, all flood and storm costs estimates for 1% AEP events; a 10% reduction in costs attributed to the technology. These assumptions and conditions are tested in extensive sensitivity analyses in Section 6.

<sup>14</sup>Including only insurance payouts as a proxy for property and business damage and disruption and government recovery costs

**Figure 3: Base Case Appraisal – Costs and Benefits**



Source: own calculations.

### Approach

This policy appraisal is based on a standard cost-benefit analysis (CBAX) framework but considering broader social costs and benefits in addition to economic costs and benefits, aligned with New Zealand Treasury's CBAX guidance. Benefits of EWC are estimated as the reduction in costs to society associated with flood and storm events, across five categories, including market benefits, fiscal benefits and social benefits:

- Direct impacts of contact with floodwaters: avoided property and infrastructure damage
- Fiscal benefits in the form of reduced government response and recovery expenditure

- Indirect impacts resulting from flooding, including disruption of activities that reduce outputs or increase costs of doing business
- Social and wellbeing benefits (reduced harm to individuals' quality of life, estimated using a proxy of the costs of mental health and injuries alongside the Wellbeing-Year (WELLBY) framework)
- Intangible impacts covering costs damage to natural habitats as well as historic and cultural capital

Costs represent the proposed government investment in EWC.

The result is value for money across a range of sensitivity analyses, including variations in discount rates, the inclusion or exclusion of Cyclone Gabrielle and a selected set of other recent events (to test scenarios of the technology being more or less efficient for medium-scale vs. catastrophic events), the inclusion or exclusion of wider economic or societal costs, different assumptions of average annual flood and storms costs, different assumptions about the percentage point reduction in flood and storm costs due to the technology, the monetary valuation of wellbeing impacts, and other analyses, under the current climate or different climate change scenarios of low and high emissions – assessed over a 50-year and 20-year time horizon.

### Benefits Attributed to Averting Market Costs

These averted costs include damage and disruption to business and property. We use the value of insurance payments as a starting proxy for the value of these and include an estimate of wider (uninsured) economic costs:

- **Insurance payments.** We estimated average annual insurance costs by taking the total insured losses from floods and storm events<sup>15</sup> with a historic (regional) Annual Exceedance Probability (AEP) of between 0.5% to 1.49% over the past 10 years. Natural Hazards Cover has been estimated to represent an additional 8% of the value<sup>16</sup>, which was added to the total. This yields an **average annual value of NZ\$ 386 million, or NZ\$ 675 million when Cyclone Gabrielle and selected other events are**

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<sup>15</sup> Insurance Council of New Zealand. (2025). Cost of natural disasters. ICNZ. Retrieved January 2026, from <https://www.icnz.org.nz/industry/cost-of-natural-disasters/>

<sup>16</sup> NZIER (2024), p. 21. Communication with NEMA confirmed that these NHC payments were not included in the estimate of government recovery costs, meaning there would be no double counting.

included. This estimate may be conservative, as it excludes losses (insurance payments) associated with more frequent flooding events.

- **Wider economic costs.** Not all flood-related costs are covered by insurance. Uninsured losses, including damage to uninsured properties, disruption to businesses, lost productivity, and damage to public assets, are a substantial additional burden. These wider economic costs represented an **average annual estimate of NZ\$ 158 million, or NZ\$ 277 million when Cyclone Gabrielle and selected other events are included.**<sup>17</sup>

### Benefits of Reduced Fiscal Costs and Loss of Revenue

Fiscal benefits represent the potential **reduction in government expenditure and lost revenue associated with flood events.** Following a major flood, central government typically incurs substantial costs through emergency response operations, infrastructure repair, recovery grants, temporary accommodation, and foregone tax revenue from disrupted economic activity. We estimate an **average annual government recovery cost of NZ\$ 335 million, or NZ\$ 604 million when Cyclone Gabrielle is included.**

### Benefits From Improving Wellbeing

Beyond the market and fiscal impacts captured above, flood events impose substantial **non-market costs** on individuals and communities. These include loss of life, physical injury, deterioration in mental health, heightened rates of family violence and other adverse outcomes. Such impacts are typically not compensated through insurance and are therefore **not reflected in the market cost estimates described above.** We estimate these impacts through **two complementary approaches.**

1. **Wider societal costs.** The first approach draws on an Australian study that quantified the social costs of natural disasters by estimating the **prevalence of death, injury, mental health conditions, and other adverse outcomes,** and then calculating the associated productivity losses and additional government costs (such as increased benefit payments). We estimate an **average annual wider societal cost of NZ\$ 599**

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<sup>17</sup> This is based on a 41% protection gap, based on Geneva Association (2025) data. This may be a conservative estimate, given that the economic losses from Cyclone Gabrielle and the Auckland floods were estimated to be around 150% to 200% of the insured losses:

Aon. (2024). *Climate and catastrophe insight*. Retrieved March 2026, from <https://assets.aon.com/-/media/files/aon/reports/2024/climate-and-catastrophe-insights-report.pdf>

Taking this assumption would give a figure over four times the amount, at NZ\$ 707 million, or NZ\$ 1,237 million when Cyclone Gabrielle and selected other events are included.

million, or NZ\$ 1,047 million when Cyclone Gabrielle and selected other events are included.

2. **Direct wellbeing costs.** An alternative and more direct approach is to estimate the subjective wellbeing loss experienced by affected individuals using the Wellbeing-Year (WELLBY) framework, and to monetise this using an established willingness-to-pay value for changes in life satisfaction. This approach more fully captures the intrinsic value of avoided suffering, rather than relying on indirect proxies such as productivity losses.

We develop and apply an estimated wellbeing impact to the total population exposed to a 1% AEP flood event in New Zealand (approximately 753,000 people), treating this as the number of individuals affected by a flood event, whether directly or by virtue of living in the local area, consistent with the methodology in the underlying study. New Zealand Treasury values 1.0 WELLBYs (defined as one point of life satisfaction measured on a 0-10 Likert scale for one individual for one year) at NZ\$ 16,784. This then yields an **average annual wellbeing cost of NZ\$ 13 million**. Note that our wellbeing impact captures the **individual wellbeing impact of mental health conditions and any injuries incurred**. An estimate of the loss due to deaths is captured in the first approach above.

These two approaches can be added together since the wellbeing impacts to the individual (estimated through the WELLBY framework) are separate and additional to the productivity losses and costs to government, which are estimated in the first approach.

### **Environment, Cultural Heritage, and Wider Non-Quantified Impacts**

Major floods and storms frequently cause damage to the natural environment and cultural heritage. Some of these impacts are already captured in the estimates above: damage that affects market revenues is reflected in the economic cost estimates, while impacts on individuals' quality of life, including those arising from environmental degradation, loss of social connectedness, and harm to cultural heritage, are captured in the direct wellbeing estimate, since life satisfaction is an all-encompassing measure that reflects changes across many drivers of wellbeing.<sup>18</sup> However, there may be longer-lasting, non-market impacts that extend beyond what is captured by these estimates. To provide an illustrative estimate of these additional costs, we draw on evidence from China and the UK on the

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<sup>18</sup> That is, impacts on the environment and cultural heritage will affect life satisfaction, which is estimated through the approach described above.

monetised impacts of flooding on the environment and cultural heritage, scaled relative to total economic costs.<sup>19</sup>

Impacts on institutional and community trust, and any resulting effects on future behaviour, were not possible to monetise, though plausible pathways linking these to wellbeing are discussed in the full report.

**Table 1: Estimated Past Average Annual Costs for Regional AEP 1% Floods and Storms Across Scenarios (NZ\$ Million, 2026 Price Year)**

<b>Cost Type</b>	<b>Scale of Estimated Average Annual Costs (NZ\$)<sup>20</sup></b>	<b>Confidence</b>	<b>Notes</b>
<b>Market Costs</b>			
Economic Costs: Damage and Disruption to Property and Business (Insured)	386	High	Figures from ICNZ for insurance payouts. <sup>21</sup> This includes an estimated additional 8% Natural Hazards Cover <sup>22</sup>
Wider Economic Costs	158	Medium	Based on protection gap of 41% for extreme weather events (2014-2023 in Australia / Oceania). <sup>23</sup> This may be conservative, given this gap between insured and full losses was 150% to 200% for Cyclone Gabrielle and the Auckland Anniversary Weekend floods <sup>24</sup>
<b>Government Costs</b>			
Recovery Costs	335	Medium-High	NEMA estimates based on government cost data: for major events <sup>25</sup> , there is roughly a 1:1 ratio between total insurance costs and costs to central government (sum of expenditure and lost revenue); for other events, total government costs

<sup>19</sup> The potential partial overlap with the wellbeing estimate is noted but has a small impact on the overall figures and does not change the scale of the argument.

<sup>20</sup> Using base case: drawing from all 1% AEP historic regional events over the past 10 years for an average

<sup>21</sup> May overestimate damage to insured properties and businesses if there are costs for moral hazard, but not considered to strongly influence figure nor confidence

<sup>22</sup> NZIER (2024), p. 21

<sup>23</sup> Geneva Association. (2025). *Safeguarding Home Insurance*.

[https://www.genevaassociation.org/sites/default/files/2025-06/safeguarding\\_home\\_insurance\\_040625.pdf](https://www.genevaassociation.org/sites/default/files/2025-06/safeguarding_home_insurance_040625.pdf)

<sup>24</sup> Aon. (2024). *Climate and catastrophe insight*. Retrieved March 2026, from <https://assets.aon.com/-/media/files/aon/reports/2024/climate-and-catastrophe-insights-report.pdf>

<sup>25</sup> Such as Cyclone Gabrielle and the Auckland Anniversary Weekend floods of 2023

## Investing in Early Warning Capability for Floods and Storms

An Appraisal of Benefits and Costs for NEMA New Zealand

			are approximately 65% of total insurance payments
<b>Wellbeing Costs</b>			
Wider Social Impacts	599	Low-Medium	Based on two case studies in Australia where social (intangible) costs were 1.1 x the tangible costs. No double counting with wellbeing values since the monetised intangible impacts include: productivity losses, cost savings to government, reduced transfer payments
Wellbeing Impacts	13	Medium-High	Confident in scale of wellbeing impact, estimates from Germany which may not extrapolate to New Zealand
Environment and Cultural Heritage	4	Low	Using international case studies (China, UK) which may not extrapolate to New Zealand cultural and environmental context. Methodologies may not represent full non-market value of environmental and cultural assets. Potential for partial overlap with individual wellbeing impacts
<b>Estimated Total Monetised Costs</b>	<b>1,495</b>		
<b>Monetised Costs With High Confidence</b>	<b>734</b>	<b>Medium-High</b>	

Source: own calculations.

### Benefits of EWC: Estimated Reductions in Flood and Storm Costs

A central uncertainty in this policy appraisal is the extent to which enhancements to New Zealand's EWC, including investment in EWS technology, will reduce the impacts of floods and storms. To address this, we draw on evidence provided by NEMA, alongside findings from the international literature, to develop a set of impact reduction estimates.

The international evidence base consistently demonstrates that effective EWS can substantially reduce disaster-related damage, disruption, and loss of life. The World Meteorological Organization reports that alerts issued within 24 hours of a hazard event can

reduce disaster-related damage by approximately 30%.<sup>26</sup> Similarly, the United Nations Office for Disaster Risk Reduction (UNDRR) finds that countries with comprehensive EWS experience mortality rates up to eight times lower than those without such capabilities.<sup>27</sup>

European studies further indicate that flood EWS can reduce flood damage costs by around 25%.<sup>28</sup> Additional research suggests that enhanced EWC can reduce post-storm infrastructure disruption by between 5% and 15%,<sup>29</sup> generating broader macroeconomic benefits through avoided service outages and reduced recovery time.

Evidence from recent New Zealand flooding events aligns with international findings. Analysis of the Canterbury floods indicates that early warning measures avoided approximately 25% to 30% of potential losses. For Cyclone Gabrielle, early warning is estimated to have reduced total potential losses in the most severely affected areas by approximately 10% to 12%.<sup>30</sup>

Together, these findings suggest that EWC already plays a meaningful role in reducing disaster impacts, and that improvements to system performance could generate further measurable benefits.

**Average and Marginal Benefits.** The benefits of enhanced EWS technology are assessed relative to a counterfactual scenario of an existing EWS with no additional investment, rather than a scenario without any EWS. This approach reflects the reality that New Zealand already operates an established early warning framework.

However, available evidence indicates that current EWC arrangements are not achieving their full potential. NEMA reviews and the development of the business case for the EMS-OS initiative identify opportunities for significant performance improvements through targeted investment in technology, integration, and capability uplift.

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<sup>26</sup> Šakić Trogrlić, R., et al. (2025). Effectiveness of early warning systems: A systematic review. *PMC*.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC12911018/>

<sup>27</sup> United Nations Office for Disaster Risk Reduction. (2023). *Global status of multi-hazard early warning systems*. <https://www.undrr.org/reports/global-status-MHEWS-2023>

<sup>28</sup> Pappenberger, F., Cloke, H. L., Parker, D. J., Wetterhall, F., Richardson, D. S., & Thielen-del Pozo, J. (2015). The monetary benefit of early flood warnings in Europe. *Environmental Science & Policy*, 51, 278–291.

<https://doi.org/10.1016/j.envsci.2015.04.016>. See also: Thielen-del Pozo, J., Thiemig, V., Pappenberger, F., Revilla-Romero, B., Salamon, P., De Groeve, T., & Hirpa, F. (2015). *The benefit of continental flood early warning systems to reduce the impact of flood disasters* (EUR 27533 EN). European Commission, Joint Research Centre. <https://doi.org/10.2788/46941>

<sup>29</sup> Estimates cited from NIWA (2017), UNDRR (2019), and OECD (2021), as provided by NEMA.

<sup>30</sup> Canterbury and Cyclone Gabrielle estimates provided by NEMA.

Effective early warnings depend not only on technical capability but also on public trust. Although the relationship is not straightforward, research shows that when trust in hazard warnings is low, individuals are more likely to seek independent validation of the threat, resulting in delay that can prove costly or even fatal.<sup>31</sup> Conversely, emergency preparedness can strengthen institutional trust.<sup>32</sup> Enhancements to EWC, including clearer, more actionable messaging that conveys the expected impact in plain language, could improve both immediate compliance with warnings and longer-term public confidence in the system.

**Assumptions for Base Case Appraisal.** The policy appraisal, therefore, models a scenario in which upgraded EWS technology improves outcomes beyond current capability levels. Based on international and domestic evidence, the base case assumes that enhanced EWC reduces potential flood and storm impacts by an additional 10% relative to current performance.

This parameter represents a key uncertainty and is tested through sensitivity analysis. Importantly, modelling indicates that the proposed investment would remain value for money even if enhanced capability reduced impacts by as little as 2%, providing a strong margin of robustness around the central estimate.

### Caveats

Several sources of uncertainty should be acknowledged in this appraisal.

First, estimates of average annual damages are based on historical data and may not fully reflect future costs. Second, some cost estimates, especially those relating to wider economic and societal impacts, are derived using top-down ratios informed by international evidence rather than New Zealand-specific data. Third, estimates of the percentage reduction in flood impacts attributable to EWS rely largely on international studies, which may not translate directly to New Zealand's context or investment settings.

The implications of these uncertainties are explicitly tested through sensitivity analyses, which include:

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<sup>31</sup> For example, Zhong, M., Xiao, L., Zhang, Q., & Jiang, T. (2021). Risk perception, risk communication, and mitigation actions of flash floods: Results from a survey in three types of communities. *Sustainability*, 13, 12389.

OECD. (2024). *OECD survey on drivers of trust in public institutions – 2024 results: Building trust in a complex policy environment*. OECD Publishing. <https://doi.org/10.1787/9a20554b-en>

<sup>32</sup> OECD. (2024). *OECD survey on drivers of trust in public institutions – 2024 results: Building trust in a complex policy environment*. OECD Publishing. <https://doi.org/10.1787/9a20554b-en>

- adopting longer historical time horizons for estimating average annual damages;
- excluding lower-confidence evidence; and
- modelling a range of assumptions relating to impact reduction, climate change scenarios, and discount rates.

The base case has been selected as a conservative estimate and across all tested scenarios, the appraisal consistently indicates that the proposed investment delivers strong value for money, demonstrating that the overall conclusions are robust to key uncertainties.

## 1. Background

EWC, including an EWS technology that serves a platform, is targeted at reducing the impact experienced from risk through a reduction in exposure.<sup>33</sup> Given New Zealand's inherent vulnerability to natural hazards, in particular to floods and storms, the ability to anticipate and prepare for emergencies is of critical importance.<sup>34</sup>

The New Zealand Government Inquiry into the North Island Severe Weather Events (NISWE) of 2023 identified several systemic issues relating to situational awareness, information sharing, and warning capability.<sup>35</sup> The New Zealand Government subsequently accepted the Inquiry's recommendations, which emphasised the need to strengthen these capabilities as a part of improving New Zealand's resilience to natural disasters, including investing in EWC as a component of broader technology investment.

The scale of New Zealand's vulnerability was underscored by the events of early 2023. The Auckland Anniversary Weekend floods and Cyclone Gabrielle caused catastrophic flooding

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<sup>33</sup> Alegría, A., Poloczanska, E., Loeschke, S., Mintenbeck, K., & Poertner, H. (2024). Towards an IPCC Atlas for comprehensive climate change risk assessments. *NPJ Climate Action*, 3, Article 193.

<https://doi.org/10.1038/s44168-024-00193-3>

<sup>34</sup> EWC primarily provides the ability to interpret emerging hazards and communicate timely warnings that inform decision-making and protective action. However, its effectiveness depends on a wider set of capabilities that support hazard sensing, situational awareness, and the coordination of operational responses.

<sup>35</sup> Government Inquiry into the Response to the North Island Severe Weather Events. (2024). *Report of the Government Inquiry into the Response to the North Island Severe Weather Events*. Department of Internal Affairs. [https://www.dia.govt.nz/diawebsite.nsf/Files/Government-Inquiry-into-Severe-Weather-Events/\\$file/Report-of-the-Government-Inquiry-into-the-Response-to-the-North-Island-Severe-Weather-Events.pdf](https://www.dia.govt.nz/diawebsite.nsf/Files/Government-Inquiry-into-Severe-Weather-Events/$file/Report-of-the-Government-Inquiry-into-the-Response-to-the-North-Island-Severe-Weather-Events.pdf)

across much of the North Island, resulting in 19 deaths,<sup>36</sup> the displacement of thousands of people, and an estimated NZ\$ 9 to 14.5 billion in total damage.<sup>37</sup> This immediately highlights the affordability challenge, and the associated urgency of investing in resilience, as these types of events are expected to be more frequent and of higher intensity.

At the peak of the event, approximately 225,000 homes were without power, and the destruction of critical infrastructure isolated entire communities.<sup>38</sup> These events highlighted the challenges of coordinating an effective emergency response without integrated, real-time information systems.

Subsequent reviews, including the NISWE (2024) report already referred to, as well as NEMA's own internal assessment, identified broader capability gaps in situational awareness, information sharing, operational tooling, and warning capability, including the absence of a modern EWC. These limitations constrained situational awareness and decision-making at national, regional, and local levels within the emergency management sector, reinforcing the case for investing in EWC, including a modern EWS capable of providing timely and actionable information to both responders and the public.<sup>39</sup> The absence of such capability also limits the ability for officials to discharge their duties and obligations effectively in an emergency response.

In response, NEMA, in collaboration with sector partners, initiated the Emergency Management System – Operating System (EMS-OS) Programme. The Programme Business Case was approved by Cabinet in April 2025. The programme addresses an urgent need for investment in NEMA's core operational systems to support both responders and the public in preparing for, responding to, and recovering from hazards and exposed risks. An EWC is one of several core capability components within this programme.

Rather than simply predicting when and where an emergency might occur, the value of an EWC lies in its capacity to trigger timely and effective responses that minimise harm and loss. By integrating real-time hazard monitoring, predictive analytics, and coordinated alerting across multiple levels of government, an EWC empowers individuals, communities, and organisations to take appropriate protective action in advance of an impending hazard.

LSE Consulting was asked by NEMA to appraise all significant benefits and costs of investing towards enhancing an EWC in New Zealand, and to assess its likely value for

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<sup>36</sup> These fatalities occurred across multiple impact mechanisms (including landslides). The Coronial Inquiry into the North Island Severe Weather Events is ongoing at the time of this policy appraisal being drafted, with final attribution of causes yet to be determined.

<sup>37</sup> New Zealand Treasury. (2023). North Island Weather Events Response and Recovery Funding.

<sup>38</sup> New Zealand Ministry of Foreign Affairs and Trade. (2023). Cyclone Gabrielle's impact on the New Zealand economy and exports.

<sup>39</sup> National Emergency Management Agency. (2024). NEMA Internal Review of Operational Response to North Island Weather Events.

money and social value using a cost-benefit analysis (CBAX) framework, in line with New Zealand Treasury's CBAX framework. There are several international estimates of the potential value for money of an EWC (including EWS) for floods and storms. The broader value of enhanced EWC is to address the set of issues identified by the New Zealand Government Inquiry into the Response to the North Island Severe Weather Events (NISWE) published in 2024. Our goal is to make the best possible value-for-money judgement regarding such an investment in view of the available data and evidence.

In what follows, we describe our approach to policy appraisal (Section 2), then detail all significant benefits (Section 3) and costs of the EWC (Section 4), as well as their likely changes depending on different climate change scenarios (Section 5). The actual appraisal can be found in Section 6, including a wide range of sensitivity analyses. Section 7 concludes.

## 2. Policy Appraisal

This policy appraisal follows the **CBAX framework**, comparing the estimated expected benefits of investing in an EWC to the proposed costs. In line with established practice for government investment decisions, the analysis aims to capture the full societal costs and benefits, i.e. impacts that extend beyond direct market transactions to include broader effects on individuals and communities.

The **benefits** of the EWC primarily consist of the expected reduction in costs associated with a flood or storm event. As described in more detail in Section 3, these benefits fall into three categories:

1. **Market benefits** (such as avoided damage to property and infrastructure)
2. **Fiscal benefits** (cost savings to government, for example through reduced expenditure on emergency response and recovery)
3. **Wellbeing benefits** (reflecting the reduction in harm to individuals' quality of life)

The **costs** represent the proposed government investment into the EWS technology.<sup>40</sup>

The **policy appraisal** is aligned with the New Zealand Treasury's CBAX framework and reports three summary measures of value for money:<sup>41</sup>

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<sup>40</sup> No evidence was identified of material social costs associated with the technology itself.

<sup>41</sup> New Zealand Treasury. *CBAX Spreadsheet Model*. <https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/plan-investment-choices/cost-benefit-analysis-including-public-sector-discount-rates/cbax-spreadsheet-model>

1. **Net present social value (NPSV)** = total expected monetised benefits to society – total expected costs
2. **Benefit-cost ratio (BCR), societal total** = total benefits to society / total costs (including initiative costs)
3. **Return on investment (ROI), societal total** = (total benefits to society – subtotal costs, excluding initiative costs) / initiative costs

All future costs and benefits are **discounted** to present values. Following New Zealand Treasury guidance, results are presented using discount rates of 2% (base case appraisal) and 8% (sensitivity analysis), providing a range that reflects uncertainty about the appropriate social rate of time preference. The **time horizon** for the appraisal is 50 years, from year 2026 onwards.

The policy appraisal focuses on flood and storm events with an estimated **annual exceedance probability (AEP) of 1%**, i.e. events that occur roughly once every 100 years. **The total population in New Zealand exposed to a flood event with an AEP of 1% is 753,000 individuals.**<sup>42</sup>

Note that, due to the small number of data points in historical time series on the costs of flood events with an estimated historic (regional) AEP of 1%, we look at an AEP of between 0.5% and 1.49% (events that tend to occur roughly once every 67 to 200 years) when extrapolating expected market and fiscal benefits from historical data. This scope was agreed during the project as the most relevant range for estimating the potential costs avoided through an EWS. However, since an EWS could also reduce costs for events with an AEP lower than 0.5% and higher than 1.5%, this approach would underestimate the potential cost savings.

**Cyclone Gabrielle**, with an estimated AEP of about 0.45%, falls just outside this range. Given its significance as the costliest flood- and storm-related disaster in New Zealand's recent history, in Section 6, we will analyse the sensitivity of our results to including Cyclone Gabrielle (and selected other events) over the past 10 years.

Note that average annual costs are estimated based on the past 10 years of flood and storm events. This represents a relatively short time window, particularly for lower-probability events that occur infrequently by definition. However, extending this time window substantially further back in time risks misrepresenting the current built environment and its associated exposure, as well as the evolving frequency and severity of extreme weather events under a changing climate. In a sensitivity analysis in Section 6, we estimate average annual costs based on the past 20 years of flood and storm events.

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<sup>42</sup> National Institute of Water and Atmospheric Research. (2025). *Flood hazard across Aotearoa New Zealand* [Dashboard]. ArcGIS.

<https://niwa.maps.arcgis.com/apps/dashboards/8c1db2b8e37841f29a57a38675388897>

### 3. Benefits

Benefits are estimated as the **reduction in costs to society associated with flood and storm events**. As outlined in the policy appraisal approach in Section 2, these benefits fall into three categories:

1. **Market benefits:** reduced costs borne by individuals, households, and businesses, including insurance payouts<sup>43</sup> and wider economic disruption such as lost productivity and damage to property
2. **Fiscal benefits:** reduced government expenditure on emergency response, recovery, and reconstruction
3. **Wellbeing benefits:** reduced harm to individuals' quality of life, including impacts on physical and mental health, displacement, and disruption to daily living

**Market and fiscal benefits** are often described as 'tangible' cost savings, since they involve observable monetary flows. Some of these savings are directly cashable. **Wellbeing benefits**, while reflecting very real experiences for the individuals affected, can be described as 'intangible' cost savings, since the associated monetary values represent estimates of social value rather than actual financial transactions. Both types of benefit are included in this policy appraisal, consistent with NZ Treasury CBAX framework's emphasis on capturing the full social impact of government investment decisions.

In estimating all significant benefits and costs, we took particular care to avoid **double counting**, to ensure that the same impact is not monetised in more than one category. We return to this issue in our sensitivity analyses in Section 6, where we selectively exclude different types of benefits.

Figure 4 sets out the range of tangible and intangible impacts associated with flood and storm events, as suggested by Deloitte Access Economics (2016).<sup>44</sup>

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<sup>43</sup> Although insurance payments are financial flows from insurers to households and businesses, the value of claims paid out serves as a proxy for the underlying damage, and thus for part of the societal cost of a flooding event. In the absence of such damage, these resources could have been used for other productive purposes.

<sup>44</sup> Deloitte Access Economics. (2016). *The economic cost of the social impact of natural disasters*. <https://www.deloitte.com/au/en/services/economics/perspectives/economic-cost-social-impact-natural-disasters.html>

**Figure 4: Tangible and Intangible Impacts Associated With Flood and Storm Events**



Source: Deloitte Access Economics (2016).

We estimate the past average annual costs of relevant flood and storm events, and then the potential reduction in these costs following the introduction of the EWC technology. Table 2 provides an overview of our estimates across scenarios (NZ\$, price year 2026).

**Table 2: Estimated Past Average Annual Costs of AEP 1% Floods and Storms Across Scenarios (NZ\$ Million, 2026 Price Year)**

	<b>Base Case</b>	<b>Wider Scenarios (Further Sensitivity Analyses in Section 6)</b>	
<b>Cost Type</b>	<b>Annual Average of Past 10 Years (Excluding Cyclone Gabrielle)<sup>45</sup></b>	<b>Including Cyclone Gabrielle and Selected Other Events<sup>46</sup> (Gabrielle+) Over Past 10 Years</b>	<b>Annual Average of Past 20 Years (Excluding Cyclone Gabrielle)</b>
<b>Market Costs</b>			
Damage and Disruption Costs (Proxy: Insurance Payouts)	386	675	207
Wider Economic Costs*	158	277	85
<b>Government Costs</b>			
Recovery Costs	335	604	177
<b>Wellbeing Costs</b>			
Wider Societal Costs*	599	1,047	321
Direct Wellbeing Costs <sup>47</sup>	13	13	13
<b>Other Costs</b>			
Wider Costs: Environment and Cultural Heritage*	4	8	2
<b>Total Monetised Costs</b>	<b>1,495</b>	<b>2,624</b>	<b>805</b>
<b>Monetised Costs Excluding Low to Medium Confidence (*)</b>	<b>734</b>	<b>1,292</b>	<b>397</b>

Source: own calculations.

<sup>45</sup> Includes all events 0.5% to 1.4%

<sup>46</sup> With an AEP of 1.5% and higher, see Appendix for list

<sup>47</sup> Estimated directly based on the wellbeing impact of flooding, the population exposed to 1% events, and the likelihood, i.e. not an annual average over past years, which means that it does not vary with inclusion or exclusion of different events

### 3.1. Market Costs Averted

Market costs averted are estimated in two components: insurance payouts averted, which serve as a proxy for direct damage to property and assets, and wider economic costs averted, which fall beyond the scope of insurance coverage.

#### 3.1.1. Damage and Disruption to Property and Business: Insurance Payouts

Annual average insured damage and disruption was estimated as the total insured losses<sup>48</sup> from flood and storm events with an AEP of between 0.5% to 1.49% over the past 10 years. This yields an **average annual insurance cost of NZ\$ 386 million<sup>49</sup>, or NZ\$ 675 million when Cyclone Gabrielle and selected other events (see Appendix for a list) are included (price year 2026).**<sup>50</sup> A lower bound is **NZ\$ 207 million when looking at flood and storm events with an AEP of between 0.5% to 1.49% over the past 20 years.**<sup>51</sup>

This figure includes the assumed additional 8% adjustment to Insurance Council New Zealand (ICNZ) costs to capture the National Hazards Commission insurance payouts<sup>52</sup>, since this could be double counting with government recovery costs.

#### 3.1.2. Wider Economic Costs

Not all flood and storm-related costs are covered by insurance. Uninsured losses, including damage to uninsured properties, disruption to businesses, lost productivity, and damage to public assets, are a substantial additional burden. These wider economic costs were estimated by applying a factor of 41% on top of insurance costs, based on the observed protection gap for extreme weather events in Australia and Oceania over the 2014 to 2023 period.<sup>53</sup> This gives us an **average annual estimate of NZ\$ 158 million, or NZ\$ 277 million when Cyclone Gabrielle and selected other events are included (price year 2026).** This may be a conservative estimate, given that the uninsured economic losses from Cyclone Gabrielle and the Auckland Anniversary Weekend floods were estimated to be around 1.5 to

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<sup>48</sup> Insurance Council of New Zealand. (2025). *Cost of natural disasters*. ICNZ.

<https://www.icnz.org.nz/industry/cost-of-natural-disasters/>

<sup>49</sup> This estimate is likely to be conservative, as it excludes insurance costs associated with more frequent flood and storm events, such as those with a 2%, 5%, or 10% AEP, for which an EWS may also reduce damage.

<sup>50</sup> Insurance Council of New Zealand. (2025), *ibid*

<sup>51</sup> This figure also excludes Cyclone Gabrielle.

<sup>52</sup> NZIER (2024), p. 21. Communication with NEMA confirmed that these NHC payments were not included in the estimate of government recovery costs, meaning there would be no double counting.

<sup>53</sup> Geneva Association. (2025). *Safeguarding Home Insurance*.

[https://www.genevaassociation.org/sites/default/files/2025-06/safeguarding\\_home\\_insurance\\_040625.pdf](https://www.genevaassociation.org/sites/default/files/2025-06/safeguarding_home_insurance_040625.pdf)

two times the insured losses<sup>54</sup>. Applying this assumption across all events would give a figure over four times the amount, at NZ\$ 707 million, or NZ\$ 1,237 million when Cyclone Gabrielle and selected other events are included.<sup>55</sup> A lower bound is **NZ\$ 85 million when looking at flood and storm events with an AEP of between 0.5% to 1.49% over the past 20 years.**

This estimate carries medium confidence, as it is derived from a top-down regional average rather than a bottom-up assessment of uninsured losses across individual sectors in New Zealand.<sup>56</sup> Given this uncertainty, we test the value-for-money conclusions when excluding **wider economic costs** in a sensitivity analysis in Section 6.

### 3.2. Fiscal Costs Averted

Fiscal benefits represent the potential **reduction in government expenditure and lost revenue associated with flood and storm events**. Following a major flood or storm, central government typically incurs substantial costs through emergency response operations, infrastructure repair, recovery grants, temporary accommodation, and foregone tax revenue from disrupted economic activity.

Average annual **recovery costs** to central government were estimated using ratios derived by NEMA from the relationship between total insurance costs and total government costs (comprising both direct expenditure and lost revenue).<sup>57</sup> For major flood and storm events, the observed ratio is approximately 1:1, i.e. government costs are broadly comparable in magnitude to total insurance costs.<sup>58</sup> For smaller events, total government costs are around 65% the value of insurance payments, reflecting the more limited role of central government in responding to less severe events.

Applying these ratios to the insurance cost estimates described above yields an **average annual government recovery cost of NZ\$ 335 million, or NZ\$ 604 million when Cyclone Gabrielle and selected other events are included** (price year 2026). A lower bound is

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<sup>54</sup> Aon. (2024). Climate and catastrophe insight. Retrieved March 2026, from <https://assets.aon.com/-/media/files/aon/reports/2024/climate-and-catastrophe-insights-report.pdf>:

This reported that the Auckland Anniversary Weekend floods of 2023 resulted in NZ\$ 5.6 billion in economic losses and NZ\$ 2.2 billion in insured losses. Cyclone Gabrielle led to economic losses of NZ\$ 6.4 billion, with insured losses of NZ\$ 2.02 billion (all in 2023 prices).

<sup>55</sup> This is not explicitly represented in a scenario but highlights the likely conservative nature of the estimates.

<sup>56</sup> A bottom-up approach would not necessarily yield a higher-confidence estimate, given the difficulty of fully identifying and valuing uninsured losses across all affected sectors.

<sup>57</sup> 'Recovery': the coordinated efforts and processes to give effect to the immediate, medium- and long-term holistic regeneration of a community following a disaster. This definition excludes the cost of investments undertaken, following an event, aimed at 'betterment', or enhancing the resilience of social, economic, natural environments to future disasters.

<sup>58</sup> Insurance Council of New Zealand. (2025), *ibid*

NZ\$ 177 million when looking at flood and storm events with an AEP of between 0.5% to 1.49% over the past 20 years.

This estimate carries medium-high confidence. Although it is derived based on observed costs for several larger and smaller events, these ratios from specific case studies are applied across the full list of relevant events.

### 3.3. Wellbeing Costs Averted

Beyond the market and fiscal impacts captured above, flood and storm events impose substantial **non-market costs** on individuals and communities. These include loss of life, physical injury, heightened rates of family violence and deterioration in mental health.<sup>59</sup> A UK longitudinal study found raised level of psychological morbidity amongst flooded participants, even at year two.<sup>60</sup> Such impacts are typically not compensated through insurance and are, therefore, **not reflected in the market costs estimates described above**. We estimate these impacts through **two complementary approaches**.

#### 3.3.1. Wider Societal Costs

Evidence from New Zealand demonstrates that adverse weather events have significant impacts on health and wellbeing.<sup>61</sup> To estimate the monetary value of these wider societal costs, we draw on an Australian study that quantified the social impacts of natural disasters.<sup>62</sup> The study assessed the **prevalence of injuries, mental health conditions, and other adverse outcomes** following disaster events, and translated these impacts into economic terms by estimating associated productivity losses and additional government expenditures, including increased benefit payments.<sup>63</sup>

Insurance payouts (which target property and related losses) tend not to compensate for these, and as a result, they are not included in the market costs. Based on case studies of a major flooding event and an earthquake, the study estimated that these wider social costs

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<sup>59</sup> Zhong et al (2018) The long-term physical and psychological health impacts of flooding: A systematic mapping, *Science of The Total Environment*, 626, 165-194, <https://doi.org/10.1016/j.scitotenv.2018.01.041>

<sup>60</sup> Jermacane, D., Waite, T. D., Beck, C. R., Bone, A., Amlôt, R., Kovats, S., Armstrong, B., Buber, J., Chalk, T. J., Dobney, A., Erens, B., Reacher, M., & Oliver, I. (2018). The English National Cohort Study of Flooding and Health: The change in the prevalence of psychological morbidity at year two. *BMC Public Health*, 18, 330. <https://doi.org/10.1186/s12889-018-5236-9>. The odds of probable psychological morbidity are higher amongst flooded survey participants who reported persistent damage.

<sup>61</sup> Laking, G., Caddie, M., Thorpe, H., et al. (2024). *Te Weu me Te Wai – Research into health and wellbeing impacts of adverse weather conditions*. Te Weu Tairāwhiti: Te Tairāwhiti.

<sup>62</sup> Australian Business Roundtable for Disaster Resilience & Safer Communities. (2016). *The economic cost of the social impact of natural disasters*. Deloitte Access Economics.

<sup>63</sup> Note that some of these are associated with a financial saving, in contrast to estimates of wellbeing which are non-cashable.

were approximately 1.1 times the total tangible (i.e. market and fiscal) costs. Applying this ratio to the combined insurance and wider economic cost estimates yields an **average annual wider societal cost of NZ\$ 599 million, or NZ\$ 1,047 million when Cyclone Gabrielle and selected other events are included** (price year 2026). A lower bound is **NZ\$ 321 million when looking at flood and storm events with an AEP of between 0.5% to 1.49% over the past 20 years.**

This estimate carries low confidence, as it is based on only two Australian case studies and applied via a single top-down ratio. A further limitation is that the Australian study monetises wellbeing impacts primarily through their downstream effects on productivity and government expenditure, i.e. costs that are, in principle, closer to market and fiscal impacts than to the direct experience of reduced wellbeing.

### 3.3.2. Direct Wellbeing Costs

An alternative and more direct approach is to **estimate the subjective wellbeing loss experienced by affected individuals using the Wellbeing-Year (WELLBY) framework<sup>64</sup>**, and to monetise this using an established willingness-to-pay value for changes in life satisfaction. This approach more fully captures the intrinsic value of avoided suffering, rather than relying on indirect proxies such as productivity losses.

The most robust study estimating the impact of experiencing a local flood event on life satisfaction is **Luechinger and Raschky (2009)**, who use a difference-in-differences design to estimate a causal effect.<sup>65</sup> The authors exploit data on individuals' life satisfaction from the Eurobarometer for the years 1973 to 1998 and data on floods from the EM-DAT database of the Centre for Research on the Epidemiology of Disasters (CRED), which includes all disasters meeting at least one of the following criteria: 10 or more people reported killed, 100 or more people reported affected, a declaration of a state of emergency, or a call for international assistance. They find that **experiencing a local flood event reduces individuals' life satisfaction by 0.10 points on a 0-to-10 Likert Scale** (rescaling 0.037 points on an originally 1-to-4 scale using a rescaling factor of [11/4], cf. Luechinger & Raschky (2009) Table 2 Column 2).<sup>66</sup> Importantly, the authors control for GDP per capita and

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<sup>64</sup> Frijters, P., Clark, A. E., Krekel, C., & Layard, R. (2020). A happy choice: Wellbeing as the goal of government. *Behavioural Public Policy*, 4(2), 126–165. <https://doi.org/10.1017/bpp.2019.39>

Frijters, P., & Krekel, C. (2021). *A handbook for wellbeing policy-making*. Oxford University Press.

Frijters, P., Krekel, C., Sanchis, R., & Santini, Z. (2024). The WELLBY: A new measure of social value and progress. *Humanities and Social Sciences Communications*, 11, 726. <https://doi.org/10.1057/s41599-024-03229-5>

<sup>65</sup> Luechinger, S., & Raschky, P. A. (2009). Valuing flood disasters using the life satisfaction approach. *Journal of Public Economics*, 93(3–4), 620–633. <https://doi.org/10.1016/j.jpubeco.2008.10.003>

<sup>66</sup> This does not constitute double counting with the wider societal costs estimated above. The Australian study monetises social impacts through productivity losses and additional government expenditure, valued at market prices. The wellbeing estimate here captures a conceptually distinct quantity: the wellbeing loss to individuals, monetised on the basis of individuals' willingness to pay for a change in life satisfaction.

unemployment growth, and so hold constant any changes in economic fundamentals brought about by floods. The **estimated life-satisfaction impact is thus the impact over and beyond any changes in the economy.**

We apply this estimated wellbeing impact to the total population affected by a 1% AEP flood event in New Zealand (approximately 753,000 people). New Zealand Treasury values 1.0 WELLBYs (defined as one point of life satisfaction measured on a 0-to-10 Likert scale for one individual for one year) at NZ\$ 16,784.<sup>67</sup> This then yields an **average annual wellbeing cost of NZ\$ 12.9 million** (price year 2026). Recall that this is estimated directly based on the wellbeing impact of flooding, the population exposed to AEP 1% events, and the likelihood, i.e. not an annual average over past years, which means that it does not vary with the inclusion or exclusion of different events.

Several caveats should be noted regarding this estimate. The study excludes small, localised flood events in thinly populated areas, meaning the estimated effect is based on larger events with broader reach. The affected population in the study includes both individuals directly impacted by floods and storms (for example, through property damage) and those indirectly affected (for example, by living in the vicinity of a flood and storm event without experiencing direct losses), and the estimate does not distinguish between these groups. Both matter, however, as even indirectly affected individuals may incur wellbeing losses from, for example, stress or anxiety. Finally, the cross-sectional nature of the individual-level data does not allow inference regarding the duration of life-satisfaction impacts. We assume a 12-month period, though some evidence suggests that the effects of floods and storms on life satisfaction may persist for up to 18 months.<sup>68</sup>

In sensitivity analyses in Section 6, we extend this period to 18 months. Moreover, we exploit uncertainty around the point estimate, by looking at its upper and lower bounds using the 95% confidence interval. We will also distinguish between impacts on insured versus impacts on non-insured individuals. Finally, we look at the upper and lower bounds around the central monetary value of 1.0 WELLBYs to elicit the sensitivity of our results regarding the monetary valuation of wellbeing impacts.

Note that our **wellbeing impact captures the effects to the individual of any injuries incurred. An estimate of the societal loss due to deaths** (based on overall ratio of societal costs to economic impacts from the Australian case studies)<sup>69</sup> **is captured in the first approach**

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<sup>67</sup> New Zealand Treasury. (2022). *CBAX tool user guidance: Guide for departments and agencies using CBAX*. <https://www.treasury.govt.nz/sites/default/files/2022-10/cbax-guide-oct22.pdf>

<sup>68</sup> von Möllendorff, C., & Hirschfeld, J. (2016). Measuring impacts of extreme weather events using the life satisfaction approach. *Ecological Economics*, 121, 108–116. <https://doi.org/10.1016/j.ecolecon.2015.11.013>

<sup>69</sup> Both approaches in this report do not use data from New Zealand on average deaths due to floods and storms. Rather, the first approach (Section 3.3.1) applies the ratio of the wider social costs compared to full economic costs, based on case studies in Australia. The societal cost due to deaths is estimated at 4% of the total social costs.

above. The appendix includes a brief discussion of alternative approaches to assessing wellbeing or social value.

### 3.4. Further Costs Averted: Environmental and Cultural Capital, and Wider Non-Quantified Impacts

Flooding events can also have impacts on the natural environment<sup>70</sup> as well as cultural and heritage capital.<sup>71</sup> These impacts will be in part captured in some of the monetised estimates above. The environmental impacts and loss of natural capital may impact partly on agricultural productivity, included in economic costs. Loss of cultural and natural assets will have an impact on wellbeing, which is quantified holistically through the WELLBY framework.

With lower confidence, we can also draw from international estimates of the additional monetised costs to the environment and cultural heritage.

#### 3.4.1. Costs to the Natural Environment

A case study from China estimated the damages to the natural environment of flood events to be US\$ 20million (NZ\$ 34 million)<sup>72</sup> in ecosystem service loss, compared with US\$ 6.1 billion (NZ\$ 10.5 billion) for economic losses.<sup>73</sup> A flood event in the UK estimated costs to wildlife of around £2.4m (NZ\$ 5.5 million), with total economic costs of £1.6bn (NZ\$ 3.7 billion).<sup>74</sup> These case studies suggest a ratio of around 0.2% to 0.3% of total economic costs.

#### 3.4.2. Costs to Cultural and Heritage Capital

The same analysis for the UK estimated that cultural and heritage capital costs could be £7.7m (NZ\$ 17.6 million), compared to the total economic costs of £1.6bn (NZ\$ 3.7 billion),

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<sup>70</sup> Zhang, Y., Li, Z., Wang, J., Ge, W., & Xu, H. (2024). Impact of floods on the environment: A review of indicators, influencing factors, and evaluation methods. *Science of the Total Environment*, 951, 175683. <https://doi.org/10.1016/j.scitotenv.2024.175683>

<sup>71</sup> Reimann, L., Vafeidis, A. T., Brown, S., Hinkel, J., & Tol, R. S. J. (2018). Mediterranean UNESCO World Heritage at risk from coastal flooding and erosion due to sea-level rise. *Nature Communications*, 9, 4161. <https://doi.org/10.1038/s41467-018-06645-9>

<sup>72</sup> Exchange rates used: 1 US\$ = 1.71 NZ\$; 1 £ = 2.29 NZ\$ (mid-market rates, 15 March 2026)

<sup>73</sup> Zhang, Y., Li, J., Wang, J., Xu, H., Qian, H., Ge, W., & Li, Z. (2025). A monetary quantification method for comprehensive flood consequences comprising economic losses, loss of life, human injuries, and environmental damage. *Journal of Cleaner Production*, 533, 146990. <https://doi.org/10.1016/j.jclepro.2025.146990>

<sup>74</sup> Environment Agency. (2018). *Estimating the economic costs of the winter floods 2015 to 2016*. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/672087/Estimating\\_the\\_economic\\_costs\\_of\\_the\\_winter\\_floods\\_2015\\_to\\_2016.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/672087/Estimating_the_economic_costs_of_the_winter_floods_2015_to_2016.pdf)

suggesting that these additional cultural heritage costs could represent 0.3% of total economic costs.

These monetised estimates can only be a proxy of the longer lasting impacts from damage to capital and heritage assets. There are likely further, non-monetised impacts not currently captured in these frameworks.<sup>75</sup>

The potential partial overlap with the WELLBY value is noted but has a small impact on the overall figures and does not change the scale of the argument.

### 3.4.3. Further Non-Quantified Impacts

Trust (both community and institutional) is strongly linked to subjective wellbeing<sup>76</sup>, and government efficiency is associated with national wellbeing, though the evidence is not conclusive on causality.<sup>77</sup>

Evidence suggests that institutional trust in governments and risk-management organisations can be eroded by natural disasters<sup>78</sup>, with areas receiving visible disaster relief experiencing smaller declines.<sup>79</sup> Conversely, OECD surveys indicate that overall institutional trust is linked to the confidence that governments can handle emergencies and that preparedness investments can help maintain trust during crises.<sup>80</sup>

Combining these threads, there are plausible pathways linking improved EWC and effective disaster management to levels of trust, with downstream implications for wellbeing. However, the direct evidence is too weak to quantify or monetise these links. Moreover, some of this effect may already be captured in our direct estimates of the wellbeing impacts of flooding, since life satisfaction is an overarching measure that encompasses changes across many drivers of wellbeing, including trust.

That said, there may be longer-term impacts that extend beyond the immediate flooding episode. Trust has, in turn, been linked to emergency preparedness, although the

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<sup>75</sup> For example, option value

<sup>76</sup> Helliwell, J. F., Huang, H., & Wang, S. (2016). *New evidence on trust and well-being* (NBER Working Paper No. 22450). National Bureau of Economic Research. <https://doi.org/10.3386/w22450>

<sup>77</sup> Bjørnskov, C., Dreher, A., & Fischer, J. A. V. (2010). Formal institutions and subjective well-being: Revisiting the cross-country evidence. *European Journal of Political Economy*, 26(4), 419–430. <https://doi.org/10.1016/j.ejpoleco.2010.03.001>

<sup>78</sup> Nakayachi, K. (2015). Examining public trust erosion after natural disasters: Lessons from the Fukushima nuclear accident. *Risk Analysis*, 35(5), 838–850.

<sup>79</sup> Frost, M. H., Kim, S., Scartascini, C., Zamora, P., & Zechmeister, E. J. (2025). Disaster and political trust: Evidence from the 2017 Mexico City earthquake. *World Development*, 189, 106927. <https://doi.org/10.1016/j.worlddev.2025.106927>

<sup>80</sup> OECD. (2024). *OECD survey on drivers of trust in public institutions – 2024 results: Building trust in a complex policy environment*. OECD Publishing. <https://doi.org/10.1787/9a20554b-en>

relationship is not straightforward. One study found greater trust in authorities in the UK and Germany associated with faster evacuation. In other contexts, higher trust in the hazard communication raised compliance.<sup>81</sup> This highlights the interconnected nature of preparedness, wellbeing, trust, and final impacts, and suggests that the benefits of an EWC may compound over time.

### 3.5. Benefits of EWC: Estimation Reductions in Flood and Storm Events

A central uncertainty in this policy appraisal is the extent to which enhancements to New Zealand's EWC, including investment in EWS technology, will reduce the impacts of floods and storms. To address this, we draw on evidence provided by NEMA, alongside findings from the international literature<sup>82</sup>, to develop a set of impact reduction estimates.

#### 3.5.1. International Evidence

The international literature suggests that effective EWC can substantially reduce flood-related damage and loss of life. According to the World Meteorological Organization, EWS alerts issued within 24 hours of an event **can reduce disaster-related damage by approximately 30%**.<sup>83</sup> European evidence indicates that flood EWS have the potential to **reduce flood damage costs by around 25%**.<sup>84</sup> Further studies suggest that EWS **can reduce post-storm infrastructure disruption by 5% to 15%**, with associated macroeconomic benefits from avoided service downtime.<sup>85</sup> The UNDRR reports that countries with limited to

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<sup>81</sup> Nicholas, J. P., Donovan, A., Oppenheimer, C., et al. (2026). How trust shapes individual resilience to natural hazards: A systematic review. *Natural Hazards*, 122, 48. <https://doi.org/10.1007/s11069-025-07816-w>

<sup>82</sup> See also: United Nations Office for Disaster Risk Reduction. (2023). *Global status of multi-hazard early warning systems*. <https://www.undrr.org/reports/global-status-MHEWS-2023>; International Labour Organization. (n.d.). *The importance of early warning systems in disaster risk reduction*. <https://www.ilo.org/resource/article/importance-early-warning-systems-disaster-risk-reduction>; UNESCO. (n.d.). *Tsunami warning system: Preparing for the unpredictable*. <https://www.unesco.org/en/tsunami-warning-system-preparing-unpredictable>; IFRC Preparedness Centre. (n.d.). *Early warning systems*. <https://preparecenter.org/topic/early-warning-systems/>

<sup>83</sup> Šakić Trogrlić, R., et al. (2025). Effectiveness of early warning systems: A systematic review. *PMC*. <https://pmc.ncbi.nlm.nih.gov/articles/PMC12911018/>

<sup>84</sup> Pappenberger, F., Cloke, H. L., Parker, D. J., Wetterhall, F., Richardson, D. S., & Thielen-del Pozo, J. (2015). The monetary benefit of early flood warnings in Europe. *Environmental Science & Policy*, 51, 278–291. <https://doi.org/10.1016/j.envsci.2015.04.016>. See also: Thielen-del Pozo, J., Thiemig, V., Pappenberger, F., Revilla-Romero, B., Salamon, P., De Groeve, T., & Hirpa, F. (2015). *The benefit of continental flood early warning systems to reduce the impact of flood disasters* (EUR 27533 EN). European Commission, Joint Research Centre. <https://doi.org/10.2788/46941>

<sup>85</sup> Estimates cited from NIWA (2017), UNDRR (2019), and OECD (2021), as provided by NEMA.

moderate EWS coverage have nearly five times more disaster-affected people than countries with substantial to comprehensive coverage.<sup>86</sup>

Evidence specific to New Zealand flood and storm events points in a similar direction. For the **Canterbury floods**, it is estimated that **approximately 25% to 30% of losses were avoided due to early warning**. For **Cyclone Gabrielle**, estimated avoided losses attributable to early warning amount to a **roughly 10% to 12% reduction in total potential losses** in the hardest-hit areas.<sup>87</sup>

Together, these findings suggest that EWC already plays a meaningful role in reducing disaster impacts, and that improvements to system performance could generate further measurable benefits.

### 3.5.2. Average and Marginal Benefits

A challenge of directly applying these percentage-reduction estimates is that many capture the full benefit of having an effective EWC compared to having no EWC at all.<sup>88</sup> The proposed investment in New Zealand, by contrast, needs to capture the benefits of an *additional* improvement to existing capability. In other words, the benefits of enhanced EWS technology are a *marginal* change and are assessed relative to a counterfactual scenario of an existing EWS with no additional investment.<sup>89</sup> This approach reflects the reality that New Zealand already operates an established emergency management framework capable of supporting an EWC.

However, available evidence indicates that current New Zealand EWC arrangements are not achieving their full potential. NEMA reviews and the development of the business case for the EMS-OS initiative identify **opportunities for significant performance improvements through targeted investment in technology, integration, and capability uplift**.

### 3.5.3. Base Case and Sensitivity Analyses

Our policy appraisal, therefore, models a scenario in which upgraded EWS technology improves outcomes beyond current capability levels. In the absence of sufficiently granular evidence of marginal improvements, or evidence to apply differentiated reduction rates to each cost category<sup>90</sup>, we draw from international and domestic evidence and apply a

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<sup>86</sup> United Nations Office for Disaster Risk Reduction. (2023). *Global status of multi-hazard early warning systems*. <https://www.undrr.org/reports/global-status-MHEWS-2023>

<sup>87</sup> Canterbury and Cyclone Gabrielle estimates provided by NEMA.

<sup>88</sup> Although the UNDDR report compares countries with limited to moderate EWS coverage to those with comprehensive coverage, it is not clear if the proposed changes in New Zealand could be representative of the step from moderate to comprehensive coverage.

<sup>89</sup> Rather than the overall benefits of EWS

<sup>90</sup> Applying differentiated estimates to more granular cost categories would not increase confidence in the results, given the mismatch between the evidence base and the cost structure used in this appraisal.

uniform reduction of 5% to 30% across all categories of flood and storm costs.<sup>91</sup> The base case appraisal takes a conservative 10% reduction as a default starting point, as it lies in the lower range of the evidence available.

**Table 3: Estimated Reductions in Average Annual Flood and Storm Costs (NZ\$ Million, 2026 Price Year)**

<b>Estimated Reduction in Costs</b>	<b>5%</b>	<b>10% (Default)</b>	<b>20%</b>	<b>30%</b>
<b>Including Full Estimated Social Costs</b>				
Base Case Appraisal (Excluding Cyclone Gabrielle)	75	150	299	449
Including Cyclone Gabrielle+	123	262	525	787
Including 1% Events Over Longer Time (20 Years)	40	81	161	242
<b>Excluding Estimated Costs With Low to Medium Confidence<sup>92</sup></b>				
Base Case Appraisal (Excluding Cyclone Gabrielle)	37	73	147	220
Including Cyclone Gabrielle+	65	129	258	388
Including 1% Events Over Longer Time (20 Years)	20	40	79	119

Source: own calculations.

## 4. Public Costs

The public costs of the EWC investment have been given to us by NEMA, and they include costs for:

1. Operating the Monitoring, Alerting, and Reporting (MAR) team
2. Technology for early warning operational systems

<sup>91</sup> Drawing from the evidence summarised above of the ranges which have been estimated

<sup>92</sup> Including only: insurance costs as a proxy for damage and disruption, government recovery costs, and monetised WELLBYs

### 3. Specific weather information and awareness of threat modelling to support EWS from partner agencies

In addition, there are **attributable one-off implementation costs estimated at NZ\$ 46.1m across the public sector**. These costs are associated with several initiatives throughout the public sector that are specific to the EWC investment and do not include any overhead costs generally for emergency management. **Ongoing operational costs are estimated to be NZ\$ 27.9m per year in any subsequent year** for maintenance and operation of the technologies. All figures are in 2026 prices.

## 5. Different Climate Change Scenarios

**Our base case appraisal assumes no change in climate conditions over the appraisal period.** That is, the estimated average annual flood costs and the size of the exposed population are held constant at current levels, and the appraisal time horizon is 50 years.

However, for an investment intended to strengthen New Zealand's long-term resilience to natural hazards, it is important to consider how flood risk may evolve under (now likely) changing climate. Research from NIWA estimates that 753,000 individuals currently live in locations exposed to flooding from 1% AEP rainfall events, and that this figure could rise to over 900,000 under a scenario of +3°C of additional warming.<sup>93</sup> In particular, it is estimated that the following populations will be exposed:

- Current climate: 753,000 individuals
- +1°C warming: 810,000
- +2°C warming: 857,000
- +3°C warming: 902,000

Under a *high-emissions scenario*, it is estimated that there will be +1°C of additional warming by 2029, +2°C by 2056, and +3°C by 2076. Under a *low-emissions scenario*, it is estimated that there will be +1°C of additional warming by 2042, +2°C by 2074, and +3°C not reached by the end of the century.

To capture these dynamics, **we extend our base case appraisal to include two additional climate change scenarios: a *low-emissions* and a *high-emissions scenario*, each assessed over a 50-year time horizon.** In each case, the **exposed population (and associated flood costs) are linearly extrapolated from year 1 to year 50**, reflecting the projected increase in exposure under the relevant warming pathway and emissions scenario. Other than that, the

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<sup>93</sup> National Institute of Water and Atmospheric Research. (2025). Flood hazard across Aotearoa New Zealand [Dashboard]. ArcGIS.

<https://niwa.maps.arcgis.com/apps/dashboards/8c1db2b8e37841f29a57a38675388897>

same cost categories and reduction assumptions described above are applied throughout, only the scale of exposure changes.

Note that these extended scenarios are not intended as forecasts. Rather, they illustrate how the value for money of investing in EWC may increase substantially as climate change intensifies New Zealand's flood risk over the coming decades.

## 6. Results

### 6.1. Base Case Appraisal

Table 4 presents the key result from our base case social cost-benefit analysis. We find a net present social value (NPSV) of NZ\$ 3.5 billion and a benefit-cost ratio (BCR) of 4.9, indicating that the EWC creates substantial social value and that its expected benefits exceed its expected costs by a factor of almost five. Since the appraisal includes no ongoing public costs beyond the initiative costs of the policy itself, the return on investment (ROI) is equal to the BCR: for every dollar invested, the EWC is expected to generate an almost fivefold return.

These costs and benefits are modelled purely for the investment in EWS for flood and storm events.<sup>94</sup> There would be further benefits where this investment in EWS could also reduce impacts of other hazards, such as earthquakes or volcanoes. In this case, the full benefit-cost ratio could be even higher.<sup>95</sup>

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<sup>94</sup> With 1% AEP events as the base case

<sup>95</sup> Depending on the scale of the marginal additional investments and marginal additional benefits. Effectively reducing impacts for these wider hazards would require further, marginal investment in, for example, certain modelling capabilities. This would provide further, marginal benefits. The current modelling only illustrates the costs of the EWS focussed on flood and storm events and the benefits for these (a subset of potential benefits).

## Investing in Early Warning Capability for Floods and Storms

An Appraisal of Benefits and Costs for NEMA New Zealand

**Table 4: Social Cost-Benefit Analysis – Base Case Appraisal**  
(NZ\$, 2026 Price Year)

<b>Benefits</b>													
<i>Discount Factor</i>	1.00	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.85	0.84	0.82 ...	0.37	
Year	0	1	2	3	4	5	6	7	8	9	10 ...	50	
	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035 ...	2075	Total
Market Costs (Averted)													
... Insurance Costs (Averted)	0	0	0	38,588,993	38,588,993	38,588,993	38,588,993	38,588,993	38,588,993	38,588,993	38,588,993 ...	38,588,993	1,852,271,640
... Wider Economic Costs (Averted)	0	0	0	15,821,487	15,821,487	15,821,487	15,821,487	15,821,487	15,821,487	15,821,487	15,821,487 ...	15,821,487	759,431,372
Fiscal Costs (Averted)													
... Recovery Costs (Averted)	0	0	0	33,520,718	33,520,718	33,520,718	33,520,718	33,520,718	33,520,718	33,520,718	33,520,718 ...	33,520,718	1,608,994,450
Wellbeing Costs (Averted)													
... Wider Societal Costs (Averted) *	0	0	0	59,851,527	59,851,527	59,851,527	59,851,527	59,851,527	59,851,527	59,851,527	59,851,527 ...	59,851,527	2,872,873,314
... Direct Wellbeing Costs (Averted)	0	0	0	1,286,806	1,286,806	1,286,806	1,286,806	1,286,806	1,286,806	1,286,806	1,286,806 ...	1,286,806	61,766,698
<b>Total Benefits in NZD</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531</b>	<b>149,069,531 ...</b>	<b>149,069,531</b>	<b>7,155,337,474</b>
PV Benefits: Discounted Total Benefits in NZD	0	0	0	140,471,548	137,717,204	135,016,867	132,369,477	129,773,997	127,229,409	124,734,715	122,288,936 ...	55,383,487	4,394,874,606
<b>Public Costs of Initiative</b>													
<i>Discount Factor</i>	1.00	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.85	0.84	0.82 ...	0.37	
Year	0	1	2	3	4	5	6	7	8	9	10 ...	50	
	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035 ...	2075	Total
Costs													
... Build EWC	0	33,500,000	12,600,000	0	0	0	0	0	0	0	0 ...	0	46,100,000
... Operate EWC	0	7,000,000	15,300,000	27,900,000	27,900,000	27,900,000	27,900,000	27,900,000	27,900,000	27,900,000	27,900,000 ...	27,900,000	1,361,500,000
<b>Total Public Costs</b>	<b>0</b>	<b>40,500,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000</b>	<b>27,900,000 ...</b>	<b>27,900,000</b>	<b>1,407,600,000</b>
PV Public Costs: Discounted Total Public Costs	0	39,705,882	26,816,609	26,290,793	25,775,287	25,269,890	24,774,402	24,288,629	23,812,381	23,345,472	22,887,718 ...	10,365,628	889,071,546
NPSV (Net Present Social Value): PV Benefits - PV Total Costs Including Public Costs of Initiative													<b>3,505,803,061</b>
BCR (Benefit-Cost Ratio): PV Benefits / PV Costs Including Public Costs of Initiative													<b>4.94</b>
ROI (Return-on-Investment): (PV Benefits / PV Costs Excluding Public Costs of Initiative) / Public Costs of Initiative													<b>4.94</b>

Notes: \* Many of these cost savings are to government through reduced transfer payments, currently calculated on aggregate.

These favourable appraisal metrics are primarily driven by an expected large reduction in wider societal costs averted, followed by expected large reductions in insurance and recovery costs averted. In contrast, the direct wellbeing losses averted play only a minor role. Note, however, that the direct wellbeing costs are on top of, or over and beyond, what is already captured by the other categories of costs, and are thus similar to residual costs averted.

These results are based on the following assumptions:

- **Time horizon:** 50 years into the future, from 2026/27 onwards
- **Discount rate:** 2%, in line with NZ Treasury guidance
- **Climate:** current climate conditions, without significant further warming (we will relax this assumption further below, by looking at different climate change scenarios under both low and high emissions)
- **Flood cost estimates:** all monetised flood costs (insurance costs, recovery costs, wider societal costs, and direct wellbeing costs) are based on flood events with an AEP of between 0.5% and 1.49% over the past 10 years, excluding Cyclone Gabrielle
- **EWC effectiveness:** a 10% reduction in flood costs attributable to the EWC
- **Wellbeing impacts:** average impacts on life satisfaction from Luechinger and Raschky (2009), undifferentiated by insurance status, assuming individuals adapt to the shock within 12 months, with 1.0 WELLBYs valued at NZ\$ 16,784<sup>96</sup>

Each of these assumptions is varied in the sensitivity analyses that follow.

## 6.2. Different Climate Change Scenarios

It is unlikely that the current climate remains constant over the next 50 years. We first look at how our results change under likely climate change under a *low-emissions* (+1°C of additional warming by 2042, +2°C by 2074, and +3°C not reached by the end of the century) and a *high-emissions scenario* (+1°C of additional warming by 2029, +2°C by 2056, and +3°C by 2076).

In both cases, the investment in the EWC continues to be good value for money. Under the *low-emissions scenario*, we obtain a benefit-cost ratio (BCR) and return-on-investment (ROI) of 5.3. The net present social value (NPSV) becomes NZ\$ 3.8 billion. Under the *high-emissions scenario*, we obtain a BCR and ROI of 5.5. The NPSV becomes NZ\$ 4.0 billion.

## 6.3. Sensitivity Analyses

We conduct a range of sensitivity analyses, respectively changing one key parameter in our base case appraisal, in order to check how our conclusions may change as a result.

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<sup>96</sup> As per current NZ Treasury CBAX guidance: [CBAX Spreadsheet Model | The Treasury New Zealand](#)

### 6.3.1. Including Cyclone Gabrielle and Selected Other Events (Gabrielle+)

When calculating the average annual costs of floods, we looked at an AEP of between 0.5% and 1.49% (events that occur roughly once every 67 to 200 years) when extrapolating expected market and fiscal benefits from historical data. This excluded Cyclone Gabrielle, which had an estimated AEP of about 0.45%, as well as many smaller events that occur with a higher frequency than an AEP of 1.49%. In both cases, the EWC may have benefits too, which we have, so far, omitted in our base case appraisal.

Including Cyclone Gabrielle and a selected set of other recent events (see the Appendix for the list of these events), we obtain annual average insurance costs that are, as expected, higher (NZ\$ 386 million in our base case appraisal vs. NZ\$ 675 million) (price year 2026). This then yields a benefit-cost ratio (BCR) and return-on-investment (ROI) of 7.8, up from 4.9 originally. The net present social value (NPSV) raises accordingly, from NZ\$ 3.5 billion to NZ\$ 6.0 billion. The value for money of the investment thus improves significantly.

### 6.3.2. Excluding Wider Societal Costs and Wider Economic Costs

Recall that our estimate of the wider societal costs carries only low confidence, as it is based on only two Australian case studies and applied via a single top-down ratio. A further limitation is that the Australian studies monetise wellbeing impacts primarily through their downstream effects on productivity and government expenditure, i.e. costs that are, in principle, closer to market and fiscal impacts than to the direct experience of reduced wellbeing.

In addition, the estimate of wider economic costs carries only medium confidence, as it is derived from a top-down regional average rather than a bottom-up assessment of uninsured losses across individual sectors in New Zealand (as are the insurance payouts, for example).

Excluding wider societal costs (averted) and wider economic costs (averted) makes the investment considerably less worthwhile, by decreasing the BCR and ROI to 2.4 from 4.9 originally. The NPSV is now about NZ\$ 1.3 billion, down from about NZ\$ 3.5 billion. Still, at expected benefits more than twice as high as costs, the investment should still go ahead.

### 6.3.3. Average Annual Flood and Storm Costs Over Past 20 Years

So far, we have calculated annual flood and storm costs over the past 10 years. While this is more representative of the costs that occur in the current climate, it also risks oversampling recent outliers. In fact, the average annual insurance costs are smaller when calculating them over the past 20 instead of the past 10 years, also reflecting that impacts of floods and storms become more severe over time (NZ\$ 386 million in our base case appraisal vs. NZ\$ 207 million) (price year 2026).

Using average annual flood costs over the past 20 years yields a BCR and ROI of 3.2, down from 4.9 originally. The NPSV reduces accordingly, from NZ\$ 3.5 billion to NZ\$ 1.9 billion. The investment continues to be good value for money, nevertheless.

### 6.3.4. Estimated Reductions in Flood and Storm Costs 5%, 20%, and 30%

There is considerable uncertainty in the estimated reductions in flood and storm costs resulting from investing in the EWC. The international literature comes up with large ranges of estimates (probably quite context-dependent), and there are issues around how to interpret the investment as either marginal or average. Our base case appraisal therefore assumed a (rather conservative) 10% estimated reduction.

**Table 5: Sensitivity Analysis – Varying Estimated Reductions in Flood Costs (NZ\$ Billion, 2026 Price Year)**

<b>Estimated Reduction</b>	<b>5%</b>	<b>10% (Default)</b>	<b>20%</b>	<b>30%</b>
<b>Including All Social Impacts</b>				
Net Present Social Value (NPSV) (NZ\$, Discounted, 2026 Prices)	1.3	3.5	7.9	12.3
Benefit-Cost Ratio (BCR)	2.5	4.9	9.9	14.8
<b>Including Only Impacts With Highest Confidence<sup>97</sup></b>				
NPSV	0.2	1.3	3.4	5.6
BCR	1.2	2.4	4.9	7.3

Source: own calculations.

Varying the range of estimated reductions in flood and storm costs between 5% (pessimistic) and 30% (optimistic) in Table 5, we find that the investment into the EWS continues to be worthwhile even under the most pessimistic assumption. Even when only market impacts are included and all social and wider economic impacts are excluded, the benefits of the EWS still continue to outweigh the costs.

### 6.3.5. Direct Wellbeing Costs: Adaptation, Bounds, and the Case of Insurance

Accounting for different adaptation paths (18 vs. 12 months, as in our base case appraisal) or using the range of 95% confidence bands around our point estimate of the effect of floods on life satisfaction, has negligible impacts on our appraisal metrics, as the direct wellbeing costs are only a minor driver of these.

<sup>97</sup> Insurance payouts, government recovery costs, and WELLBY estimates (WELLBY estimates represent less than 1%)

The case of insurance is more interesting. Luechinger and Raschky (2009) show that the effect of floods on life satisfaction is essentially zero if individuals are insured (cf. Luechinger & Raschky, 2009, Table 5 Column 1). In New Zealand, the insurance rate is nearly 90%: while only around 3% to 5% of residential properties nationwide are completely uninsured, this percentage rises to 10% to 15% in coastal or flood-prone regions such as Hawke's Bay, Westport, and parts of Auckland, particularly after Cyclone Gabrielle (2023). As the relevant population for our analysis is the exposed population in at-risk areas, we can assume a high insurance rate of approximately 85% to 90% accordingly.

For simplicity, assume that everybody in our exposed population is insured. This is akin to excluding direct wellbeing losses (as costs averted). Again, as these are only a minor driver of our appraisal metrics, we continue to see a NPSV of NZ\$ 3.5 billion, and a BCR and ROI of 4.9.

### 6.3.6. Different WELLBY Monetary Values

Accounting for different WELLBY monetary values (NZ\$ 7,343 and NZ\$ 26,225 vs. NZ\$ 16,784 as in our base case appraisal) again has negligible impacts on our appraisal metrics, as the direct wellbeing costs are only a minor driver of these.

### 6.3.7. Discount Rate of 8%

NZ Treasury's CBAX guidance requires a sensitivity analysis regarding discounting, namely, to use a discount rate of 8% instead of 2% (as is the default in our base case appraisal).

Changing the discount rate to 8% over our 50-year appraisal horizon gives us a BCR and ROI of 4.4 (as benefits and costs are discounted equally) and reduces the NPSV to NZ\$ 1.2 billion, down from NZ\$ 3.5 billion.

### 6.3.8. Triangulation

For context, a range of studies commissioned by Regional and Unitary Councils Aotearoa and summarised in *Before the Deluge 2.0*<sup>98</sup> provide BCR estimates of between 5.1 to 9.1 for investments in 'flood protection infrastructure'. However, these are not like-for-like estimates for investments in EWC, which is the focus here.

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<sup>98</sup> Regional and Unitary Councils of New Zealand. (2023, November 30). *Before the deluge 2.0: Updated case for co-investment in flood management infrastructure following Cyclones Hale and Gabrielle*. Resilient River Communities. <https://www.resilientrivers.nz/files/1702942838674.pdf>

On the other hand, a 2018 NZIER study<sup>99</sup> attributes BCR estimates of over 10.1 to investments in public weather forecasting and warnings.

These are higher but not strictly comparable to our findings.<sup>100</sup> It is worth emphasizing, however, that these studies typically do not include broader social and environmental costs and benefits.

## 7. Discussion and Limitations

This policy appraisal provides evidence that the proposed investment in an EWC for floods and storms in New Zealand represents strong value for money. Under our base case appraisal, the benefit-cost ratio (BCR) of 4.9 indicates that the expected benefits outweigh the costs by a factor of almost five, and this finding is robust across a wide range of sensitivity analyses. Under plausible climate change scenarios, the case for investment strengthens further as the exposed population and associated flood and storm costs increase over time.

Several limitations should, however, be acknowledged when interpreting these results.

**Evidence on damage reduction.** The estimates of how much an EWC can reduce flood and storm costs are drawn primarily from the international literature and from New Zealand-specific evidence provided by NEMA. Most of this evidence captures the full benefit of having an EWC relative to having no system at all, rather than the marginal benefit of improving an existing one. While there is clear evidence that New Zealand's current systems have significant room for improvement, the precise mapping from investment to marginal benefit reduction remains uncertain. We address this by applying a deliberately wide range of reduction estimates (5% to 30%) in our sensitivity analyses, while using a rather conservative 10% in our base case appraisal.

**Reliance on top-down ratios.** Several cost estimates in this appraisal, including wider economic costs (based on the Australia/Oceania protection gap), wider societal costs (based on two Australian case studies), and fiscal costs (based on insurance-to-government-cost ratios), are derived from top-down ratios rather than bottom-up assessments specific to New Zealand. While these represent the best available evidence

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<sup>99</sup> Gill, D., Siddharth, P., & O'Connor, D. (2018, February). *The value of MetService's public weather forecasts and weather warnings* (Final report to MetService and the Ministry of Transport). New Zealand Institute of Economic Research.

[https://www.nzier.org.nz/hubfs/Public%20Publications/Client%20reports/the\\_value\\_of\\_metservice\\_final\\_report\\_february\\_2018.pdf](https://www.nzier.org.nz/hubfs/Public%20Publications/Client%20reports/the_value_of_metservice_final_report_february_2018.pdf)

<sup>100</sup> Due to the differences in investment as well as the challenges of estimating marginal improvements in EWC.

known to us, they introduce uncertainty that should be borne in mind. In each case, we have been transparent about the confidence level and have excluded lower confidence estimates from the base case appraisal where appropriate.

**Wellbeing estimation.** The direct wellbeing cost estimate is based on a single, methodologically robust European study (Luechinger & Raschky, 2009) using data from 1973 to 1998. While this remains the most credible causal estimate of the impact of floods on life satisfaction, it may not fully reflect the New Zealand context in terms of flood characteristics, housing stock, community resilience, or institutional response capacity. The assumed 12-month duration of wellbeing impacts is conservative; if anything, extending this to 18 months (as explored in a sensitivity analysis) increases the estimated benefits.

**Potential for double counting.** We have taken care to avoid double counting across our three benefit categories. Wider societal costs (estimated via productivity losses and government expenditure) and direct wellbeing costs (estimated via life-satisfaction impacts) are conceptually distinct, but some overlap cannot be entirely ruled out. Our sensitivity analyses, which selectively exclude individual cost components, allow decision-makers to assess the robustness of our results under different assumptions about the degree of overlap.

**Scope of the appraisal.** This policy appraisal focuses on flood events with an AEP of 1%. It does not capture the potential benefits of an EWC for more frequent flooding events (2%, 5%, or 10% AEP), nor for other natural hazards such as earthquakes or tsunamis, for which the EMS-OS platform would also provide capability. To the extent that the EWC reduces costs across a broader range of events than those captured here, our estimates are likely to be conservative and a lower bound. That said, the expected benefits are even higher than the costs in this case. The appraisal may also underestimate the value of uninsured costs to the natural environment or cultural heritage, which represent additional sources of long-term value at risk from natural disasters such as floods and storms.

**Short historical time window.** Average annual flood and storm costs are estimated based on the past 10 years of events. This is a relatively short window for estimating the costs of low-probability events. A longer window would increase the number of observations but risk misrepresenting the current built environment and the evolving frequency of extreme weather under climate change. We explore the sensitivity of our results to a 20-year estimation window, which confirms the value for money of the EWC investment.

**Climate change scenarios.** The extended climate change scenarios (+1°C, +2°C, and +3°C) under low and high emissions are illustrative rather than predictive. They are based on projected increases in the exposed population from NIWA modelling and assume a linear extrapolation of costs from year 10 to year 50. In practice, the relationship between warming, flood frequency, flood severity, and population exposure is likely to be non-linear and subject to considerable uncertainty. These scenarios should, therefore, be interpreted as indicative of the direction and potential magnitude of change, rather than as precise forecasts. A further consideration is that climate change may interact not only with the scale of flood and storm exposure but also with the effectiveness of EWC itself. If warming leads to more sudden, less predictable flood and storm events, for example through increased flash flooding or more erratic storm patterns, the capacity of an EWC to provide

timely warnings could be diminished. We have no data to assess this interaction, and our scenarios hold the assumed effectiveness of the EWC constant across all warming pathways.

Despite these limitations, the appraisal consistently indicates that the proposed EWC investment represents strong value for money across all plausible scenarios. The base case BCR of 4.9 is conservative in several respects: it focuses on a narrow band of flood and storms events and assumes no climate change. This suggests that the true value of the investment is likely to be much higher.

We recommend that NEMA proceed with the investment and consider commissioning further work to refine the estimates as more granular New Zealand-specific data become available, particularly on the marginal effectiveness of EWC improvements and on the wellbeing impacts of flooding in the New Zealand context. In fact, implementing the new EWC system may provide a unique opportunity to collect such data.

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## Appendix

**Table 6: Gabrielle+ (List of Selected Events Included in Wider Scenario)**

<b>Event Location</b>	<b>Nature (ICNZ Category)</b>	<b>Date</b>	<b>Historic Likelihood (AEP % p.a.) (Regional)</b>	<b>Private Insurance Costs (NZ\$ m) in 2025 Prices (Excluding NHC Payments)</b>
<b>2025</b>				
South Island	Storm	26-29/06 2025	1.0	37.4
NZ weather	Storm	29/04-1/05 2025	1.0	20.3
Cyclone Tam - Upper NI	Storm	15-19/04 2025	1.0	51.4
<b>2024</b>				
SI Otago	Storm	1-4/10 2024	1.25	34.3
NI East Coast	Storm	25-27/06 2024	1.25	30.3
<b>2023</b>				
NI Weather	Storm	9-10/05 2023	3.5	44
Cyclone Gabrielle	Storm	11-17/02 2023	0.45	1,970.2
Auckland Anniv. Wkend	Flood	27/01-2/02 2023	0.75	2128
<b>2022</b>				
Aotearoa Storms	Storm	18-25/11 2022	3.5	23.5
Nelson-Tasman	Flood	18-21/08 2022	2.50	34.4
Marlborough + rest of NZ	Flood	18-21/08 2022	0.85	40.6
NZ Weather	Storm	24-27/07 2022	2.0	19.1
SI Weather	Storm	17-21/07 2022	1.5	23
NZ Weather	Storm	11-13/07 2022	2.0	20.3
NI & SI Weather	Storm	9-14/06 2022	3.5	22.8
NI Weather	Flood	21-29/03 2022	2.5	136.3
<b>2021</b>				
Gisborne	Flood	3-5/11 2021	1.125	4
West Auckland	Flood	30-31/08 2021	2.5	73.7
West Coast	Flood	16-19/07 2021	0.5	116.2
Wellington	Flood	16-19/07 2021	3.5	21.4
Upper SI	Flood	16-19/07 2021	2.5	20.8
Canterbury	Flood	29/05-1/06 2021	1.0	56
<b>2020</b>				
Marlborough-Nelson	Storm	26/12 2020	1.0	61.6
Greater Wellington	Flood	29/11-1/12 2020	1.0	6.6
Napier	Flood	9-10/11 2020	1.0	107.9
Upper NI	Flood	17-20/07 2020	1.25	54.8
Upper NI	Storm	26-27/06 2020	1.25	21.6
Southland	Flood	3-8/02 2020	1.5	36.7
<b>2019</b>				
Nationwide	Flood & Storm	3-12/12 2019	1.5	19.1
Timaru	Hail Storm	20/11 2019	0.75	213.2

## Investing in Early Warning Capability for Floods and Storms

An Appraisal of Benefits and Costs for NEMA New Zealand

Taranaki & Auckland	Storm	10-13/08 2019	1.25	9.9
West Coast	Wind & Flood	26-27/03 2019	1.0	5.2
<b>2018</b>				
Northland & Bay of Plenty	Flood	14-15/07 2018	1.25	4.7
Gisborne & Hawkes Bay	Flood	11-12/06 2018	1.25	5.1
Upper NI & Hawkes Bay	Flood	3-4/06 2018	1.25	5.5
Nationwide	Sevr W & Flood	27-29/04 2018	3.0	27.3
Cyclone Gita	Cyclone	20/02 2018	1.25	45.8
Cyclone Fehi	Cyclone	1/02 2018	1.0	59.2
Nationwide	Sevr Wthr	4-7/01 2018	1.25	44.2
<b>2017</b>				
South Island	Flood	20-22/07 2017	1.0	40.5
Nationwide	Svr Wthr	12-14/07 2017	1.25	16.2
Cyclone Cook Remnants	Cyclone Remnants	13-16/04 2017	1.25	22.3
Cyclone Debbie Remnants	Cyclone Remnants	3-7/04 2017	1.25	118.9
Upper NI	Flood	7-12/03 2017	1.25	80.4
Dunedin	Flood	13/02 2017	1.25	2.2
Nationwide	Svr Wthr	18-23/01 2017	1.25	11.3
<b>2016</b>				
Auckland & Environment	Flood	2-3/10 2016	1.25	0.8
Nationwide	Storm	7-9/09 2016	1.25	5
Auckland	Flood	29/06 2016	1.25	3.2
Coromandel, Auckland	Flood	17/04 2016	1.25	0.8

Source: list provided by NEMA.

### Alternative Calculations for Wider Societal and Wellbeing Costs

**Societal costs of death and injury.** An alternative approach to applying the Australian case studies would be to use estimates of average annual deaths and injuries, and apply values of a statistical life and costs to government to these estimates. NZ-specific studies suggest an average of 0.4 deaths per year from flooding<sup>101</sup>, excluding Cyclone Gabrielle, up to as high as 5 per year from extreme events.<sup>102</sup> Applying the value of a statistical life from the NZ Treasury CBAX<sup>103</sup> gives annual values of NZ\$ 6.6 million up to NZ\$ 83.5 million. These bounds are not too dissimilar to the NZ estimates drawn from the Australian case studies, where the societal costs of deaths were 4% of the total societal costs. Applied to the estimated figures in the New Zealand context<sup>104</sup>, this would represent NZ\$ 2.6 million in the base case or NZ\$ 45.3 million when Cyclone Gabrielle and selected other events are included.

**Willingness to pay for reduction in risk.** An alternative approach for the individual valuation of the wellbeing benefit would be to use estimates of the household willingness to pay (WTP) for a “significant reduction in the risk of flooding”. DEFRA (2004) estimates the equivalent of NZ\$ 750 per household per year for a significant reduction in risk of flooding. Applied to 0.2 million households in NZ exposed to 1% events would give a total of NZ\$ 211m per year. This is much larger than the approximate NZ\$ 1.3 million per year estimated through the WELLBY approach, which is based on people’s own experiences. This could in part reflect the relatively low monetary value of the WELLBY but is also likely to be beyond the upper bound of the change in question. The WTP asks related to a “significant reduction in the risk of flooding”, whereas the improvements in the EWC are more likely to reduce the scale of the impact, when a flooding event occurs.

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<sup>101</sup> NZIER (2024)

<sup>102</sup> Grout, L., et al. (2022). *An exploration of the human health impacts associated with seven decades of severe weather events in Aotearoa New Zealand: The need for better data*. University of Otago.




[https://www.otago.ac.nz/\\_data/assets/pdf\\_file/0027/332865/an-exploration-of-the-human-health-impacts-associated-with-seven-decades-of-severe-weather-events-in-aotearoa-new-zealand-the-need-for-better-data-report-841638.pdf](https://www.otago.ac.nz/_data/assets/pdf_file/0027/332865/an-exploration-of-the-human-health-impacts-associated-with-seven-decades-of-severe-weather-events-in-aotearoa-new-zealand-the-need-for-better-data-report-841638.pdf)

<sup>103</sup> NZ\$ 16.6 million in 2026 prices

<sup>104</sup> Based on insurance payouts and the estimated ratio to wider societal costs



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