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Aotearoa NZ, Global Catastrophe, and Resilience Options: Overcoming Vulnerability to Nuclear War and other Extreme Risks

version 1.0

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NZCat & Adapt Research Ltd

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Report prepared by the Aotearoa NZ Catastrophe Resilience Project Team (NZCat).

NZCat is a philanthropically funded, volunteer supported, collective of researchers and professionals with a vision for Aotearoa NZ's resilience to global catastrophe.

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Disclaimer: Views in this report do not necessarily reflect the views of the authors' organisations. As is natural in a collaborative effort, authorship does not imply that every author fully endorses every statement.

Intended Audience: The content in this report is wide-ranging and should be helpful for a range of audiences. The report can help inform decisions on structure and governance of national risk management processes. Details of sector-by-sector vulnerabilities, along with initiatives suggested by experts, could help inform industry approaches to global catastrophe. The description of context and challenges post-catastrophe could help support communities and local governments to identify likely local problems and devise plans to address them. International audiences can use this country-level template to help develop their own nuclear war/winter and other global catastrophe hazard profiles and solutions.

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Executive Summary

This report is about nuclear war and Aotearoa New Zealand (NZ), but it's much more than that. It raises the issue of global catastrophic risks (GCR) generally, how these may contain most of the risk to NZ, and how a remote island nation can build resilience. This report is a call to action, and an outline of what action could look like.

If you take one message from the evidence and case studies presented, it should be that NZ needs to systematically assess GCRs and prioritise resilience options. This would address not just the real risk of nuclear war, but the suite of GCRs and their potentially severe impacts on infrastructure, trade, connectivity, international relations, climate, economy, society, and therefore national wellbeing.

NZ should develop overarching, coordinated, and anticipatory governance of GCR risk. Governance could take the form of a Parliamentary Commissioner for Extreme Risks, a Chief Risk Officer, or similar entity (see p.59 below), responsible for:

- A systematic all-hazards approach to GCRs, with a publicly facing National Risk Assessment and Risk Register connected to cross-cutting resilience options.
- International coordination on major cross-border risks, especially with Australia.
- Cost-benefit analysis to prioritise solutions, recognising aggregate likelihood across global risks as well as cascading consequences.

Global Catastrophic Risks

Decades of increasing global interdependency, coupled with progressive instability, mean the likelihood of global catastrophe is rising. Risks that originate elsewhere, but are not malicious threats directed at NZ, slip through the gaps in NZ risk management systems. Yet, given their scale, these risks plausibly contain most of the potential harm to which NZ is exposed. GCRs include, but are not limited to, extreme pandemics, massive volcanic eruptions, great power conflicts, or nuclear war.

Global catastrophe on a scale that kills 10% of all humanity, entailing disaster for remote NZ, is forecast with a high likelihood, 6–51% by 2100 (p.12).

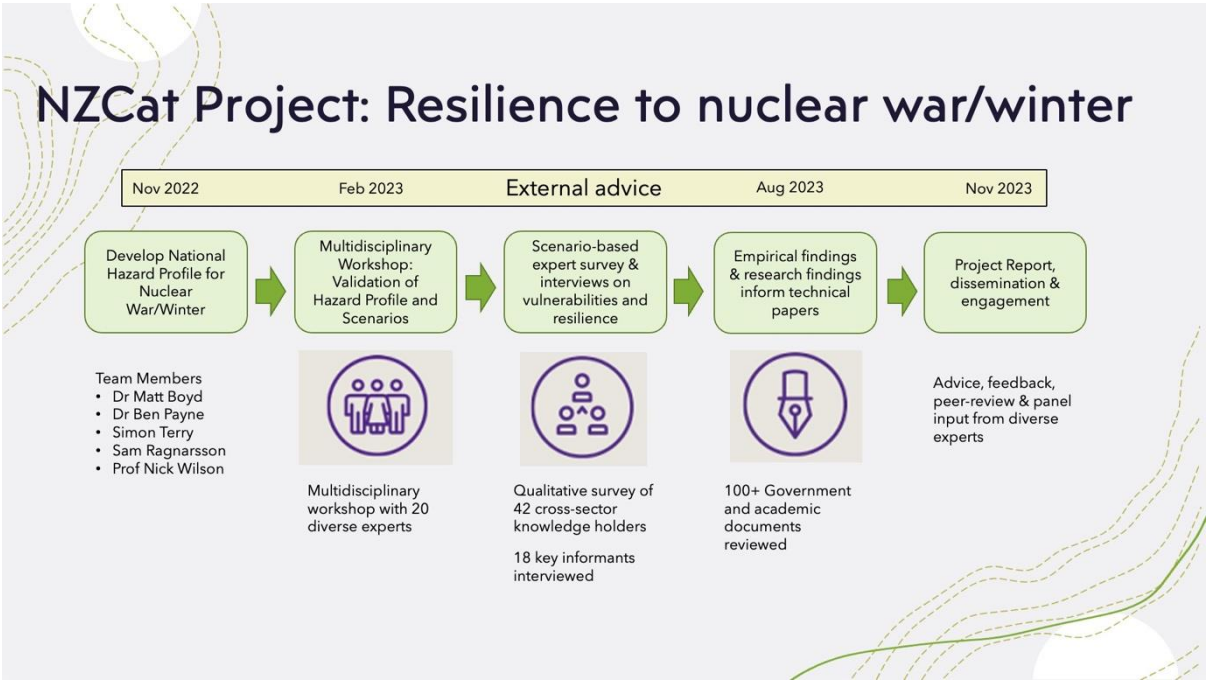
The NZCat research team chose nuclear war, and its risk to NZ, as a representative GCR for case study. The analysis assumes NZ is a non-combatant nation not directly targeted by nuclear weapons.

Solve for nuclear war, solve for global catastrophe: Northern Hemisphere nuclear war is a paradigmatic global threat, and given the common consequences across potential GCRs, resilience to the cascading consequences of nuclear war would build resilience to other risks as well.

Destruction not just disruption: Nuclear war would severely impact NZ via three key mechanisms (p.20), namely (1) physical destruction of critical global infrastructure, (2) possible electromagnetic pulses (EMP) disabling global technology, and (3) nuclear soot obscuring the sun and reducing global food production (nuclear winter). In combination these impacts threaten trade isolation for NZ that could lead to economic and social collapse.

This report presents findings about likely GCR consequences, and resilience options, based on document reviews, a Hazard Profile, multidisciplinary expert workshop, qualitative scenario-based survey, in-depth interviews with key knowledge holders, a series of technical papers, and panel discussion (Figure 1).

Figure 1: NZCat mixed methods assessment of nuclear war risk & NZ's resilience



Critical Sectors: The Big Four

We focused on how the 'big four' core sectors of food/agriculture, energy, transport, and ICT/digital could be impacted by nuclear war/winter. These sectors critically underpin functioning society and industry. Major interdependencies among these and other sectors mean that degradation of one means degradation of all (Figure 2).

For each sector we describe the research findings and provide a one-page summary ('cheat sheet') framing vulnerabilities and resilience options. Each summary sheet provides an overview of possible pre-event strategies (denoted in orange), post-event response plans (blue), and potential co-benefits of acting (green).

The resilience options are evidence-informed, or proposed by experts, and cover sector/industry reforms, central government actions, local/community actions, research and development, investments, response plans, and likely co-benefits. The overviews and options should be discussed as a nation, further developed, evaluated, compared for cost-benefit, and actions prioritised. This should happen in joined up fashion across sectors, to form an integrated national GCR strategy and plan.

Food (p.28) production and distribution is at risk from a break down in supply of industrial inputs like fertiliser, agrichemicals, seed, and fuel, as well as the climatic impacts of a nuclear winter, all of which reduce yield. NZ needs a National Food Security Strategy and plans to pivot production to conserve input consumption post-catastrophe. NZCat technical papers survey issues of food calorie need, and frost resistance (p.31).

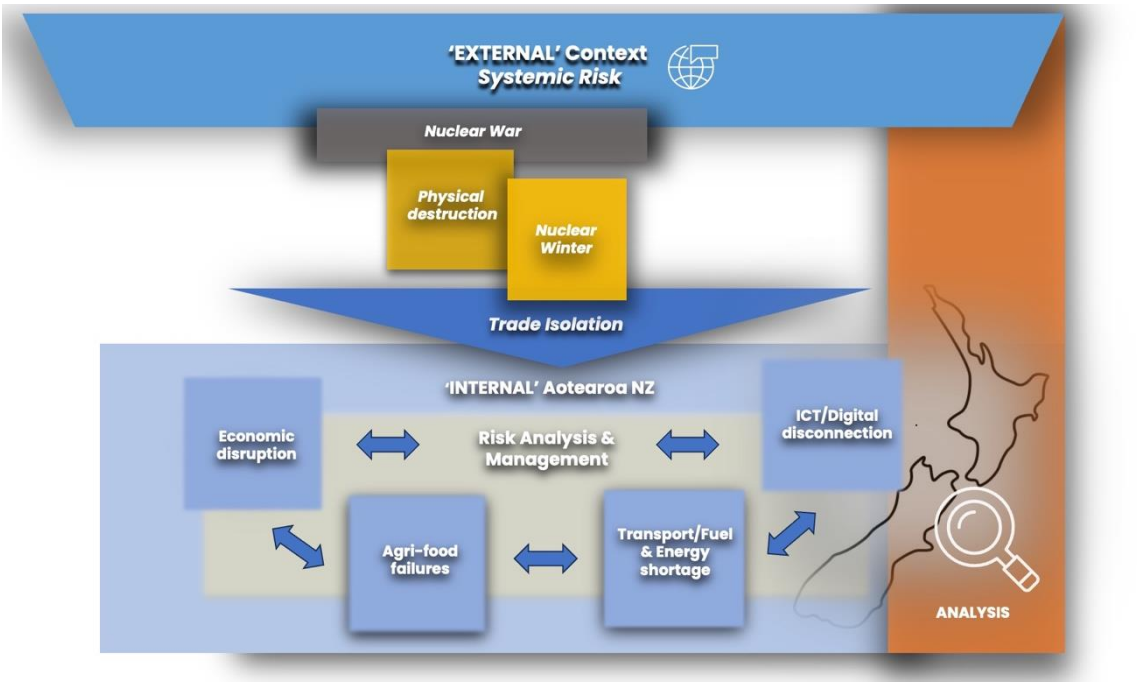
Energy (p.37) supply would suffer from loss of liquid fuel imports, system degradation due to maintenance issues, and a downturn in renewable energy production in nuclear winter conditions. NZ needs a minimal supply of locally produced liquid fuel, and an improved fuel response plan. An

NZCat technical paper (p.45) quantifies the biofuel feedstock and refining needed to support minimal agriculture.

Transport (p.46) could fail due to loss of global shipping, inadequate fuel supply, low local shipping and rail capacity, inability to trade, no interisland transport redundancy, and inaccessible urban services. NZ could consider investment in transport other than road trucking, also electrification, biofuel options, improved urban planning, and infrastructure cooperation with Australia.

ICT/digital (p.52) is essential for all sectors and at risk from failure or destruction of overseas data centres, undersea cables, and satellites. Severance of global connectivity could be managed with a Government Digital Communications Continuity Plan and investment in NZ digital infrastructure and expertise, as well as scenario testing.

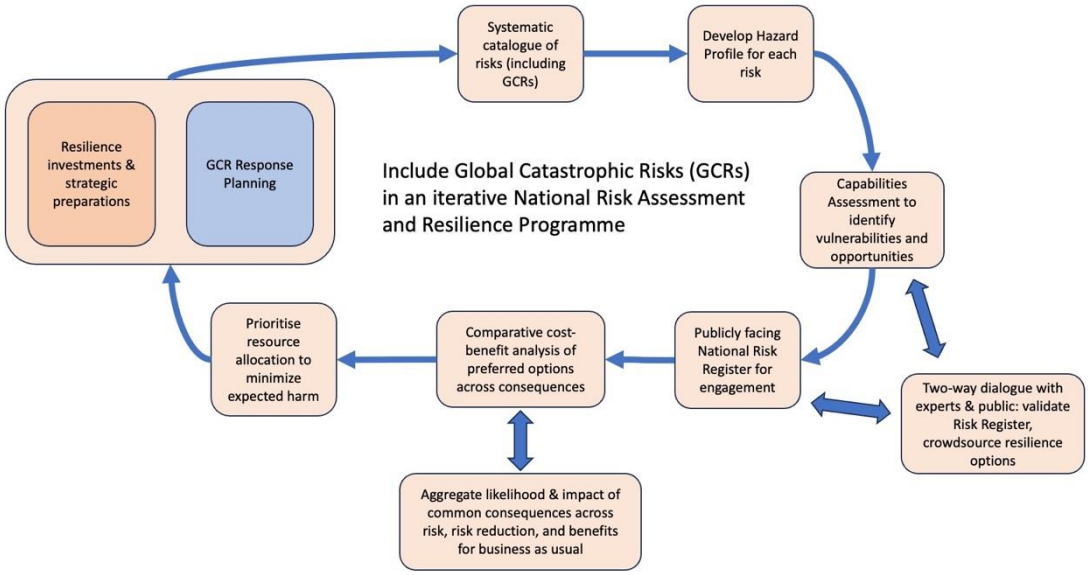
Figure 2: The impacts of a Northern Hemisphere nuclear war on NZ could collapse industry due to likely trade isolation and interdependencies among sectors



Risk Governance and Study Themes

GCR Governance & Risk Management (p.58) need to take a systematic and truly all-hazards approach because many GCRs have common and cascading likely consequences, exhibit convergent risk, and cannot be analysed in isolation. National overarching GCR governance could ensure that potential global catastrophes, rare but devastating events, and emerging non-traditional risks, are assessed, and resilience options developed. Critically important are a systematic National Risk Assessment, publicly facing National Risk Register, anticipatory governance of catastrophic risks, as well as a set of sector-by-sector security and resilience strategies and plans that cut across GCRs (Figure 3). NZCat technical papers describe some of these (p.64). Legislation should mandate and support these processes. Risk information should be shared with communities, and public dialogue fostered through processes such as citizen assemblies, while avoiding use of 'hectoring' risk language. We illustrate a vision for GCR governance on p.63.

Figure 3: NZCat research and technical analysis supports a systematic and publicly facing approach to global catastrophic risk management (p.63)



Ten additional 'major issues' (p.72) canvassed in less detail include water supply, economy, trade, industrial inputs, manufacturing, border issues, health security, social response and governance, legal/regulatory issues, and Māori considerations. Concise sections on these include potential nationwide failure of digital transactions, as well as need for cooperation, communication, consultation, and regional/local/community resilience approaches.

10 Cross-cutting themes (p.88) also emerged from the research.

1. The main problem of GCRs is likely cascading failure across multiple systems due to complex interdependencies.
2. The main solution is all-hazards GCR risk governance, with cross-border coordination, and prioritisation of resilience measures.
3. Investing in all capital (natural, human, social, physical) boosts preparedness, response, and recovery post-catastrophe, and enhances societal resilience to other risks.
4. Government, industry, and communities should collaborate and share risk information for resilience.
5. NZ must have a plan to ensure basic needs in extended (months/years) trade isolation.
6. Beyond making critical infrastructure *resilient*, NZ needs alternative investments for *resilience* (ie a Plan B).
7. Cooperation is key for resilience, and it is crucial to develop and share national narratives that solutions are possible.
8. Local governments and communities are vital for catastrophe resilience, needing risk information and resources to develop local solutions.
9. NZCat identified concerns, but also many ideas for catastrophe resilience; more should be compiled and across other sectors.
10. Nuclear war resilience initiatives benefit many risk scenarios; value and cost-benefit assessments should reflect this.

Resilience Nuggets: The NZCat team collected a suite of suggestions and case studies pertaining to nuclear war and other GCRs, which we present in boxes throughout this report. These are intended to inspire potential responses across government, industry, and communities in NZ. Some nuggets are examples of practice elsewhere, others are options to discuss and evaluate.

Human Civilisation & Co-benefits: Humanity grapples with issues like overconsumption, ecological imbalances, and climate change, while also facing potential sudden disasters like nuclear war. Market forces alone can't adequately address these risks, and without proper management, abrupt catastrophes could lead to rapid collapse of civilisation (p.96). International cooperation on GCRs is vital. With proper planning, nations like NZ, given its unique characteristics, might withstand major global disasters better than most. But NZ needs to address vulnerabilities and plan for global catastrophes. Co-benefits will likely accrue in other areas when taking an all-hazards approach to GCRs. These benefits include improved resilience to other risks, such as local natural hazards, as well as reduced climate emissions, and improved health, industry, and security. Acknowledging the risk of global catastrophe, and doing something proactive about it, is at heart a positive story.

NZCat Project Resources are listed in the Appendix (p.99). These include links to technical papers, presentations, blogs, and media that provide additional background or elaborate on important issues of vulnerability and resilience to global catastrophe.

A Resource for Resilience Action

A path forward exists among the resilience options in this report (p.98) and the 'cheat sheets' show who can act and how. Integrated, overarching, long-term GCR governance and a public National Risk Assessment connected to an analysis of capabilities, would help prioritise actions. Actions should address the common consequences across a range of hazards and threats and consider sectors and impacts beyond those we had the time and resources to examine. A set of sector-specific resilience strategies and response plans could ensure basic needs can be met in any global context. Government support for important community resilience efforts can deliver positive cost benefit.

In the face of potentially unparalleled challenges, NZ could stand poised, with true resilience, harnessing collective concern, foresight, and innovation, to secure a prosperous and sustainable future for all. NZ could lead the charge with integrated thinking and planning across the complex systemic risks and risk cascades described in this report.

PART A: Introduction & Methods

Image credit: MidJourney

Introduction

What is this report?

This report is the first major report of the Aotearoa New Zealand Catastrophe Resilience Project (NZCat).[1] NZCat is a volunteer collaboration, supported by philanthropic funds, with a vision for a resilient and flourishing Aotearoa New Zealand (NZ) in the face of global risks. This report introduces the largest risks NZ faces, global catastrophic risks (GCRs).

Some GCRs emerge from long-term trends such as climate change and ecological overshoot. However, these trends are punctuated by abrupt global catastrophes (eg, the Covid-19 pandemic). For NZ to flourish, both long-term and abrupt risk must be addressed.

In this report we analyse one example of a major abrupt global catastrophe, Northern Hemisphere nuclear war. We detail this hazard and report NZ's vulnerability and resilience based on empirical research.

This report provides evidence to support a policy agenda that would mitigate the risk of nuclear war to NZ. However, nuclear war is only one hazard among many, and hazards and trends interact. Therefore, this report is also an example, and can serve as a template, for a systematic and comprehensive assessment of other risks, convergence among risks, and a national risk mitigation strategy, to ensure a resilient NZ.

Why this report?

In 2022, The NZ Treasury concluded that the nation's future wellbeing depends on the nation's resilience to future shocks.[2] Resilience depends on the capability of collective institutions and the quality of decision-making systems to prepare for and respond to risks. A lot of important risk management happens in NZ already (as we illustrate below), yet some risks slip between the gaps in the present siloed approach. This is especially true of risks originating elsewhere, for which NZ is not an intended target of harm. Additionally, there have been repeated recent calls from within and outside of government for more risk information and public dialogue about hazard, risk, mitigation, and resilience.[3]

This report aims to bolster current gaps in the national public risk conversation by specifically examining the risk of Northern Hemisphere nuclear war, a key risk that originates elsewhere, is not a malicious threat to NZ, and where public information, and resilience options, are lacking. This report takes a systematic approach to nuclear hazard, compiling empirical information from key stakeholders, and offers a set of wide-ranging policy approaches that could mitigate this risk. However, broader lessons can be learned, and many findings apply to global catastrophic risk more generally.

The upshot of effective GCR assessment and mitigation is that NZ has a chance of ensuring social and economic stability in the face of significant 'ordinary' risks and a chance of ensuring survival and future flourishing if confronted with global catastrophe.

Strategic Context

Several global trends suggest that future global shocks are probable. NZ has experienced a history of global shocks. These include the Great Depression and World War II, the 1966 wool price shock, oil shocks, global financial crises, and pandemics, among others.[4] NZ's National Security Long-term Insights Briefing identifies increasing global competition, advancing technology, climate change, and pandemics.[5] While the Ministry of Foreign Affairs and Trade cites global shifts from rules to power, from economics to security, and from efficiency to resilience.[6] We are witnessing shifts toward regionalism and conflict, potentially exacerbated by competition over resources including food, water, energy, hardware, data, and expertise. There is division, mis- and dis-information, and people appear less willing to engage on cooperative endeavours. Overall, the number and severity of risks is increasing, and knowledge of some risks, such as climate change is becoming more secure, and their impacts more likely.

Global Catastrophic Risks (GCRs)

Global catastrophic risks are catastrophes that may cause widespread and significant global harm, such as a large and sudden reduction in global population, and/or failure of critical socio-technological global systems. Human existential risks are those GCRs that could lead to human extinction or an existential catastrophe. Examples of GCRs include extreme pandemics, nuclear war, technological catastrophes (eg, AI mishap), massive volcano eruption, global food shock, tail climate risks, asteroid/comet impact, or severe solar storms, among others.

A 2023 forecasting study concluded that global catastrophe (defined as 10% or more of all humans dying within a 5-year period) has a 6–51% chance by the year 2100.[7] Participants with a successful forecasting track record (superforecasters) ranked nuclear war as the most probable global catastrophe, ahead of an AI catastrophe, a natural pandemic, and an engineered pandemic.

NZ is experiencing increasing risk from a range of hazards, including the local impacts of climate change. Cyclone Gabrielle in February 2023 was one recent and devastating example. However, GCRs hold special prominence in the risk landscape due to their expected harm. Given that GCRs are not unlikely, and could have devastating consequences, they plausibly contain most of the risk to which the world and NZ is exposed, even in the short term.[8] Additionally, psychologists have shown that cognitive biases lead people to systematically downplay and overlook these risks.[9]

Crucially, the consequences of many global catastrophes overlap, with impacts on trade, food supply, energy, transport, communications, and climate. The probability of these disruptions is then the aggregate probability across all these risks (they can't be analysed in isolation) and the value of investments in resilience must consider the benefits across all GCRs. Nuclear war harbours the potential for a wide range of devastating consequences (Table 1). In a somewhat imprecise sense, it is a case of 'solve for nuclear war – solve for all global catastrophe'.

Table 1: Solve for Nuclear – Solve for All: Nuclear war is not the only potential global catastrophe, but many may have common adverse consequences for NZ

Selected impacts on NZ	Nuclear war	Extreme pandemic	Climate change	Global cyber catastrophe	Great Power conflict	Massive volcano*	Solar flare	Asteroid, comet impact*
Climate	↓	~	↓	~	~	↓	~	↓
Fuel supply	↓	?	↓	?	↓	↓	?	↓
Industrial inputs	↓	↓	↓	?	↓	↓	?	↓
Agricultural yield	↓	?	↓	?	?	↓	?	↓
Energy production	↓	?	↓	↓	?	↓	↓	↓
Shipping	↓	↓	?	?	↓	↓	?	↓
Road transport	↓	?	?	?	↓	↓	?	↓
Internet	↓	~	?	↓	?	?	↓	?
Cloud compute	↓	~	?	↓	?	?	↓	?
Economic activity	↓	↓	↓	↓	↓	↓	↓	↓
Social cohesion	?	?	?	?	?	?	?	?

*Especially if impacting critical global pinch points and/or causing volcanic/asteroid winter

Table note: Catastrophes cause harm through various processes. Nuclear war could cause destruction (eg, death, infrastructure), disruption (eg, trade), electrical failure (EMP), and climate impacts. Other catastrophes could result in many of the same kinds of consequences. Analysing nuclear war, and preparing resilience against it, can help prepare resilience against many potential global catastrophes.

Risk Management

International approach to GCRs

International risk experts recommend more international coordination and capacity building to address major risks, including GCRs and existential risks to humanity. United Nations (UN) commissioned research advises that lower-probability, high-impact risks be explicitly included in existing funding instruments.[10] The 2022 UN Global Assessment Report on Disaster Risk Reduction, *Our World at Risk*, called for transformative governance to ensure a resilient future in the face of increasing occurrence and intensity of disasters.[11] In 2021, the UN Secretary General's report *Our Common Agenda* expressed concern for future generations and emphasised the need to focus on building immunity to catastrophic risks including pandemics and technological risks.[12] The Organisation for Economic Cooperation and Development (OECD) anticipates future risks, including potential existential threats such as misaligned artificial intelligence or engineered pandemics. The World Economic Forum annually publishes a Global Risks report,[13] which includes some of the most severe risks. However, these analyses and directives are only slowly leading to action in individual countries.

Many countries undertake systematic national risk assessments and publish a publicly facing National Risk Register, NZ does not. For example, the UK details 89 risks including pandemics, massive volcanoes (VEI7+), and 'nuclear miscalculation' in its 2023 National Risk Register.[14] The UK Government also has a Resilience Framework, that puts value for money at the heart of resilience, noting that anticipatory measures are most cost-effective.[15]

The United States passed the Global Catastrophic Risk Management Act (2022), which mandates interagency risk assessment across specified GCRs, and the development of federal inter-agency plans to ensure basic needs are met following a GCR.[16] The US National Academy of Sciences published a 2023 report on 'Risk Analysis Methods for Nuclear War and Nuclear Terrorism,'[17] which highlights the strengths and weaknesses of risk assessment approaches and concluded there is a need to improve understanding of the physical, psychological, societal, and political consequences of nuclear weapon use.

Existing risk management approaches should include GCRs, yet many do not, or are only just starting to. The present low prioritisation for mitigation and prevention of GCRs worldwide is not consistent with the level of risk these hazards and threats pose and more balanced and systematic consideration of all risks is needed.

Management of Nationally Significant Risks in NZ

Risk management in NZ does not specifically address many of the potential GCRs. This is not to detract from the risk management work that does occur, it is just that the relevant mandate and resourcing does not appear to exist.

The Department of Prime Minister and Cabinet (DPMC) oversees the approach to national risks. DPMC's strategic intentions include, 'leading effective, strategically focused National Security and Emergency Management Systems.' This includes acting through the National Emergency Management Agency (NEMA) to reduce risk and enable communities to prepare, respond, and recover from emergencies.[18]

The risk management landscape has evolved with the release of a 2022 National Security Long-term Insights Briefing,[19] a 2023 National Security Strategy,[20] 2023 Emergency Management Bill, and DPMC's 2023 Critical National Infrastructure Regulation consultation.[21] There is also a confidential national risk register and DPMC's website lists a set of nationally significant risks.[22] However, this list does not include key GCRs (as we detail in Appendix B) and there are many reasons why a national risk register should engage the public.[23]

The management of national risks in NZ has defined silos. NEMA focuses on natural hazards, largely with a response focus. The National Security Strategy focuses mostly on agential threats directed at NZ. We note the 2023 National Security Strategy has updated earlier statements such as 'actively protecting NZ from malicious threats to our national security interests, from those who would do us harm' (found in earlier Cabinet papers) to 'threats that would do [NZ] harm', thereby potentially, and appropriately, broadening the scope of National Security.

The NZ Lifelines Council produces three-yearly Infrastructure Vulnerability Assessments. The NZ Infrastructure Commission has an Infrastructure Strategy,[24] and Government Infrastructure Action Plan,[25] though these tend to focus on resilience to climate risks. There are some gestures towards resilience to global shocks in the Ministry of Transport's *Freight and Supply Chain Strategy*,[26] and the Productivity Commission's consultation on economic resilience.[27] The latter organisation has called

for a Commissioner for Future Generations as an important anticipatory agent. The Infrastructure Commission has scheduled work on future generations but not until 2027-31.

National disaster risk management in many countries, NZ included, is geared towards response and emergency services. Yet, GCRs require anticipatory and whole-of-government interventions (as we saw with Covid-19), in the present, to manage uncertainty, risk, and resilience. This is especially true because efficiency and resilience are often in tension. The Auditor General found that NZ was not as prepared for the Covid-19 pandemic as it should have been.[28] The 2023 Auckland flood response review concluded that, citizens 'deserve and should expect a plan' to ensure that system deficiencies are not replicated in future emergencies.[29] Similarly, NZ citizens deserve and should expect a plan to ensure basic needs can be met following GCRs.

The range of risk management mechanisms outlined above do not contemplate GCRs. There is little publicly accessible analysis of the potential impacts of major threats and hazards that originate outside of NZ, are not agential threats directed at NZ, but spread and interact with other factors to catastrophically impact the entire world. We are slowly learning from the Covid-19 pandemic, but another example of such a risk is Northern Hemisphere nuclear war.

Nuclear war

Nuclear war could originate accidentally, by false alarm, unauthorised launch, or deliberate attack. With approximately 12–14,000 nuclear warheads in the world,[30] there is a risk of a major nuclear war. The forecasting study mentioned above reported a 3–11% chance of a nuclear catastrophe severe enough to kill more than 10% of humans by 2100. The devastation and cascading consequences of such a catastrophe cannot be overestimated. In the 1980s the NZ Nuclear Impacts Study (NZNIS) concluded that trade disruption would have immense and unprecedented impacts on NZ (Box 1, below),[31] and a 2022 report by the McGuinness Institute reiterate this risk.[32] Recent modelling studies conclude that there could be catastrophic impacts on agriculture with global famine. We detail these potential impacts later in this report.

The risk of nuclear war exists and is plausibly rising. Ideally, nuclear war would be prevented, and intense efforts have gone into this through diplomacy, via international forums, and philanthropic endeavours. However, there is active conflict among nuclear powers (with NATO support for Ukraine in its effort to defend against Russia's invasion, border skirmishes between China and India, as well as India and Pakistan, and Israel involved in active conflict). China is expanding its arsenal bringing about a new tri-polar nuclear problem, with nuclear doctrine needing to account for three great nuclear powers. Other nations are modernising their weapons, and there are risks associated with new automated technologies. Philanthropic funding for nuclear war prevention and research into the impacts of nuclear war is decreasing, yet these impacts are very uncertain. A rational risk mitigation strategy would allocate resources to prevention, de-escalation, and to mitigating the impact of catastrophe should preventive and de-escalatory measures fail.

Civilisation collapse

Nuclear war or other GCRs could plausibly bring about the collapse of socio-technological systems, in what might be described as 'civilisation collapse'. Such GCRs are in a qualitatively different class, as they might be unbearable. This is important when considering our tolerance of risk.

In the 1960s it was estimated that 400 nuclear weapons could collapse the Soviet Union (by killing 25% of the population and destroying 67% of industrial capacity). This apparently remains current nuclear doctrine.[33] The UN concluded in 1989 that nuclear war would bring severe socioeconomic

consequences given an interconnected world. Tight globalisation along with a tendency to optimisation and efficiency have increased the fragility of modern global systems. Shocks to this kind of system can cause tipping points and cascades, with devastating consequences.

Interconnections create complexity but also dependence. Connections can break quickly, but the dependence remains.[34] Without appropriate reserves, redundancies, contingencies, diversification, and 'circuit breakers', there is a risk that global shocks cause the systems humans depend upon (such as food, energy, and communication systems) to collapse.

A nuclear war would have characteristics associated with past civilisation collapses. These include inter-state conflict, impacts on climate, potential revolt/rebellion, intra-societal conflict, and major changes in trade. However, countries can act to mitigate the risk of collapse, because external shocks interact with endogenous factors to cause collapse. Additionally, recovery from collapse depends on capital stocks, including human, natural, social, and physical capital, which can be nurtured.

Our Vision

This report makes the case for a systematic resilience programme to address the risks of nuclear war and global catastrophe. Our vision is a NZ resilient to the impact of these GCRs. A broad movement is needed (across policy, industry, and communities), and we illustrate what key features of that movement could look like, including governance options, resilience options, and where wise investments could be made to protect New Zealanders.

We selected nuclear war as a case study for good reason. There are a 'big four' of major global risks, climate change, biological threats, artificial intelligence (AI), and nuclear weapons. NZ risk assessment mechanisms are already evaluating climate resilience. The country has just experienced, and hopefully learned from the Covid-19 pandemic. AI may pose large scale threats in some near or distant future. However, nuclear war is a risk right now. Prevention is preferable, but non-combatant nations like NZ may have limited agency in preventing catastrophe. Planning for the worst is necessary.

The 1986/87 NZNIS (mentioned above) was innovative in being multi-sectoral and sought to understand the cascading impacts and interactions within and between sectors (Box 1). However, no meaningful risk reduction activity resulted. Furthermore, important factors have changed since the 1980s, for example the ubiquity of digital technologies. It is time for a thorough reassessment of this risk.

We contend that an 'all hazards' approach to national risk is best. But 'all hazards' must actually mean *all of the hazards*, at least those with the largest potential expected harm. Addressing the largest risks will typically have co-benefits for other risks, and for business-as-usual, we explain how in what follows.

Pessimism about global risk seems prevalent, and we hope to show through a methodical analysis, that there are means to protect NZ society from the worst impacts of global catastrophe.

Even in the face of existential risk, existential hope can be found if we make wise choices about prevention and resilience. This project is a society-wide project, we have engaged stakeholders, we have engaged government and academia (within our limited resources), and we hope that the national risk conversation can develop from here, publicly, transparently, with accessible information about national risks and GCRs for all who want it. We hope that this report is just the start of future work on nuclear risk and NZ's resilience to GCRs.

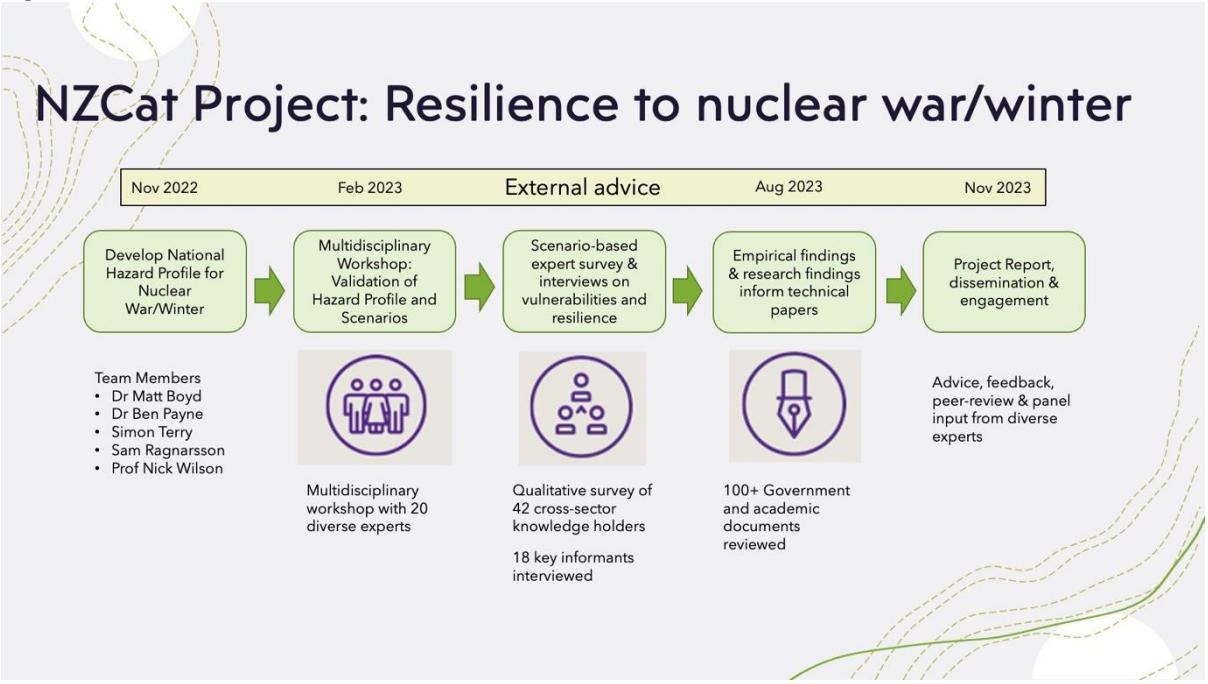
Opportunities

NZ has an opportunity to incorporate GCRs into existing risk management processes. But it has a potentially greater opportunity to redesign and resource national risk governance so that there is an overarching, systematic and comprehensive approach to GCRs. This approach should identify and then act to manage the greatest expected harms to the country, with rational targeting of risk management activities in ways that provide the best expected value for money. Actions should aim to maximise mitigation across risks (cross-cutting), rather than just within silos of activity.

Mitigation approaches may involve strategic actions ahead of time, and response actions after the fact. In what follows, we give examples of opportunities for both. Many of our findings will generalise to other countries, though specifics of geography or economy and society will mean not all findings will apply in all places. **We work thoroughly through one scenario, but there is an opportunity for this work to be repeated for each GCR**.

Project overview

Figure 4: NZCat's 2023 mixed methods assessment of nuclear war risk and NZ's resilience



Structure of the Report

The report proceeds by first detailing the project methods. The key questions for the empirical research are best summarised as 'what impact would nuclear war have on NZ?' and 'what could be done ahead of time, or after the fact, to mitigate this impact?' Details of the answers to these questions for four critical sectors follow. The answers show the immense potential consequences of nuclear war. Given that nuclear war is just one of many potential GCRs, the next section considers how NZ might govern and manage these risks. The report continues with brief details of 10 other key issues beyond the initial four critical sectors, and risk governance, which warrant further analysis. The report concludes with comments on the possibility of global civilisation collapse, and the wider significance for humanity of NZ's management of GCRs. Appendices present other project resources, a catalogue of national risks, tables summarising the main intervention options covered by the report, and references.

Box 1

The 1980s NZ Nuclear Impacts Study[35]

More than 30 years have passed since the NZ Nuclear Impacts Study's (NZNIS) groundbreaking work.

- The NZNIS published its findings in book form in August 1987. The study used surveys, interviews, role-plays, and a set of 20 background papers, to estimate the impact of a Northern Hemisphere nuclear war on NZ.
- The work found the most important impacts to be felt through collapse of global trade, as combatant and non-combatant Northern Hemisphere nations dealt with what would be the most significant internal catastrophe they have ever faced.
- Radiation and physical destruction were found not likely to affect NZ. Potential impacts were more likely to be systems failures across health, agriculture, energy, trade, transport, communications, social responses, the impacts on government and sector interactions.
- Four interacting factors were identified that raise the risk to NZ:
    - Trade-dependency
    - Increasing vulnerability of complex industrial and societal systems
    - Interdependence between sectors
    - Lack of planning
- A 'Phase II' study was proposed, and options developed at the time, which would have improved public knowledge, coordinated a rationale for preparing contingency plans, and identified strategic areas where NZ's vulnerabilities could be reduced. Although supported by Ministries, Phase II was vetoed at higher bureaucratic levels.

Why did the NZNIS not lead to change?

We can speculate on why the NZNIS findings were never further actioned:

1. It has been suggested that security officials were wary that building resilience to nuclear catastrophe would send the wrong signals to 'the enemy'.
2. The Iron Curtain came down and a false sense of security emerged.
3. Resilience measures are a public, global, and intergenerational good, but responsibility to undertake the measures is diffuse, political/communal appetite is needed – the neoliberal revolution ran against long-term planning and collective responsibility. The potential co-benefits (for more common risks) arising from resilience measures relating to nuclear war, were not recognised.
4. Political systems tend to favour management of immediate problems, and decision makers are reluctant to make present sacrifices for gains that may accrue beyond their terms.
5. Human psychological biases (including the availability heuristic and scope insensitivity) make objective assessment of major catastrophic risks difficult.

However, resilience measures would protect against a range of global catastrophes and reduce harm and suffering. This seems a worthy goal. Perhaps democratic or constitutional reforms are necessary, such as longer political terms, or apolitical risk officials with longer terms in office. Perhaps we need improved institutional decision-making processes, or robust cost-effectiveness analyses to demonstrate the business case for investing in risk mitigation. Perhaps incentives such as minimising insurance costs are needed, yet war is often excluded from policies. Perhaps 1% of the cost of government infrastructure projects could be ring-fenced for global catastrophe risk analysis and national resilience measures. Perhaps this should go to a referendum.

Methods

Preparation

In November 2021, months before Russia's invasion of Ukraine in 2022, NZCat members, supported by philanthropic funding, began to study the effects of nuclear winter on island nations, continuing their prior research on pandemics and island resilience.[36] The findings,[37] released amid the Ukraine conflict, were covered by 60+ news outlets and highlighted not just the severe risks, but also a 35-year gap in NZ's publicly facing nuclear war risk assessments.

Supported by additional philanthropic funding, NZCat initiated a one-year project in November 2022 to assess NZ's vulnerability to nuclear war. The team initially consulted with the author of the 1980s NZNIS, DPMC representatives, and other consultants.

We chose to use workshops, surveys, and interviews, and aimed to create a comprehensive Hazard Profile for nuclear risks to frame the research. The project team included full-time contribution from a catastrophic risk researcher, part-time input of a disaster risk expert and public health physician, and two volunteer advisors. All project components involving expert participants were conducted in accordance with approval from the University of Otago ethics committee (Ref: HC23/006).

A National Risk Assessment Approach

This study focused on assessing the risk of nuclear war, as if the study was part of a wider National Risk Assessment.

A National Risk Assessment (NRA) systematically compiles information about various hazards and threats of national, not merely regional significance, using a common method. The process is helpful for risk dialogue, risk comparisons, risk prioritisation, and preparedness planning across multiple risks.[38] The process of conducting an NRA is typically demanding, complex, multidisciplinary, and cross-sectoral. Many countries conduct and publish formal NRAs, for example the UK,[39] Norway,[40] and Switzerland.[41]

NZCat's first step was to develop a Hazard Profile for nuclear war/winter from the perspective of NZ. A Hazard Profile is a general description of a hazard including its location, extent (or severity), historical occurrences, and probability of future occurrences. The information in the Hazard Profile includes multicriteria impact and multicomponent likelihood. We followed a standard method, namely the Swiss approach,[42] which was developed by experts from Swiss public administration, academia, and the private sector, drew on international standards and guidelines, and had been validated in a joint workshop.

National Risk Assessments have potential weaknesses, and we aimed to address some of these. Shortcomings may include an inappropriate time horizon, scenarios chosen, discount rates, and decision rules.[43] Also, many national risk registers are only partially complete, and omit an analysis of capabilities and resilience measures.[44] We include these latter aspects in the report.

We hope that the resources developed by NZCat can help inform a future NZ National Risk Assessment (NRA). Our Hazard Profile covers only the risk of nuclear war, and it should be read in conjunction with hazard profiles developed for all other nationally significant risks to allow comparison and national resource allocation according to appropriate decision rules. Readers of this

report are strongly encouraged to read the Hazard Profile,[45] to find detailed information that provides context for the present report.

Nuclear War/Winter Hazard Profile

The nuclear war/winter Hazard Profile was updated, revised, and corrected through a workshop held on 9 February 2023,[46] involving 20 experts and stakeholders from the public sector, private sector, and academia using an iterated process of expert elicitation. Participants included international experts on nuclear war, as well as NZ sector representatives, and experts on disaster risk management. Briefly, the expert workshop participants completed a pre-workshop elicitation exercise and held a full day of discussions with the aim of converging on views about the likelihood and consequences of the 'major' scenario (Box 2). Likelihood was expressed as 'plausibility', accounting for estimates of the degree of intent and ability possessed by likely perpetrators of nuclear war, with the technical and operational feasibility of the scenario (Figure 5). Consequences were expressed as the summed monetised impact, of the mean expert ratings, across 12 impact domains (Table 2).

Box 2

NZCat 'major' nuclear war scenario

The midrange ('major') scenario described in the NZCat Nuclear War/Winter Hazard Profile contemplates a Northern Hemisphere nuclear war, where 250–500 nuclear weapons of 10–100 kilotonnes each are detonated, many on Northern Hemisphere cities. 10–30 Teragrams (equivalent to megatonnes) of soot are ejected into the stratosphere from fires and there is a resulting nuclear winter with 4.0 degrees Celsius of mean global cooling.

Examples: All-out India-Pakistan nuclear war in 2025, OR limited US-Russia nuclear war with principally counterforce and command centre targeting.

Brief description of scenario: Coincident safety system failures lead to the accidental detonation of a nuclear weapon within Russian territory. In the context of an ongoing conventional war, Russian leadership cannot rule out nuclear attack and retaliate with a strike against a NATO military target. Immediate escalation occurs and the US and Russia launch 100s of weapons at military and command and control targets, these include strikes against capital cities. Simultaneous conventional attacks wreak mass destruction against Northern Hemisphere infrastructure including ports, airports, bridges, satellites, fibre optic cables, data centres, fuel and energy infrastructure, including key pinch points. 30–75 million people are killed immediately. Weeks of chaos follow as radiation disperses, deaths mount, normal business and trade functions halt, and communications are destroyed. Stratospheric soot immediately starts to cool the Northern Hemisphere and the mean global temperature falls 4 degrees C within weeks and lasts into the following years. Food production in North America, Europe, and Russia falls 60-90% in the second year. As regional famines take hold, countries turn inwards, hoard commodities, and global trade is severely disrupted. NZ suffers from massive trade disruption and some modest impact on crop production (from cooler temperatures and reduced sunlight).

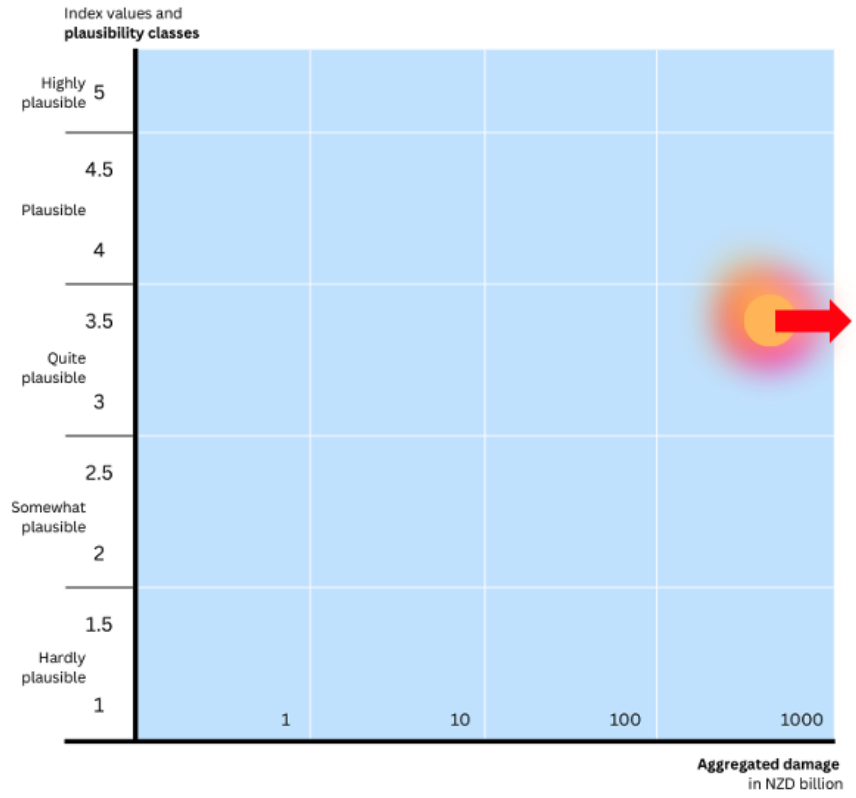
Table 2: Twelve impacts of the 'Major' nuclear war scenario on NZ (mean of expert estimates, n=12)

Impact*	Quantitative estimate (mean)	Monetised estimate (mean)
Fatalities	22,000	NZ$130 billion
Injured/sick	195,000	NZ$10 billion
People in need	330 million person days	NZ$80 billion
Damaged ecosystems	31% of NZ land area equivalent	NZ$25 billion
Asset losses/costs	NZ$250 billion loss	NZ$250 billion
Economic performance	NZ$240 billion loss	NZ$240 billion
Supply shortfalls	175 million person days	NZ$90 billion
Public order	265 million person days	NZ$130 billion
Territorial integrity	Temporary very severe violation	NZ$55 billion
Cultural property	Loss of many regional/national	NZ$1.5 billion
Reputation	Minor impact on standing	NZ$10 billion
Loss of confidence in the State	Considerable damage/months	NZ$55 billion
TOTAL Expected Value of Harm		**NZ$1,077 billion**

* Impacts as defined by Swiss National Risk Assessment methodology,[47] with intensity rated by workshop participants considering NZ context.

Figure 5 (below) demonstrates how experts concluded that a Northern Hemisphere nuclear war impacting NZ was 'quite plausible' and would likely result in more than NZ$1 trillion of harm.

Figure 5: Risk Matrix for NZCat 'major nuclear war scenario': plausibility vs monetised consequences for NZ (arrow indicates that expert estimates of consequences *increased* when they shared insights with each other)



Expert Survey and Interview Study

The workshop identified that response to nuclear war/winter depends critically on functional systems for food, energy, transport, and communications. These sectors have been repeatedly identified as pivotal in catastrophe (eg, by the NZNIS in the 1980s, by international strategists, and in previous academic research). We focused on these sectors, along with economic impacts, and risk management, in a qualitative survey and interview study of experts.

The survey was sent to potential respondents identified based on sectoral expertise and knowledge. Respondents read a shortened version of the Hazard Profile scenario and answered eight free text questions by describing the impact of the scenario and potential mitigation measures. The major impact described in the scenario was catastrophic NZ trade isolation.

Through the survey, we obtained detailed responses from 42 individuals about the scenario impact and resilience options. Survey participants represented the sectors of agriculture/food, energy, transport, ICT/digital, economy/finance, manufacturing, and supply chain. Participants had diverse professional backgrounds, ranging from farmers and producers to risk experts, policy directors, CEOs, economists, and more, representing the NZ public sector, academia, industry, and think tanks.

Two NZCat team members examined the raw survey data and identified critical impacts and potential preparedness and response actions within, and across, the selected sectors, as described by respondents. We discuss the survey findings in what follows, and a full report is available online.[48] One of the survey questions prompted respondents to identify knowledge holders likely to have deeper insight into this risk and issues of its successfully management. These became our initial interview participants.

We contacted interviewees recommended by survey respondents to obtain more in-depth information. Additional interviewees were added in snowball fashion, to achieve coverage of the four key sectors previously identified, as well as experts in risk assessment, disaster management, and economics (Table 3). The 18 interviews were semi-structured, with questions based on information about impact and mitigation approaches obtained in the survey. Lists of scenario impacts, possible mitigation measures, and general themes were extracted from interview transcripts independently by two researchers. Responses were anonymised.

Document Review & Adjunct Research

To supplement our mixed methods empirical research, we reviewed key NZ Government documents pertaining to risk, resilience, and plans and strategies across the 'big four' key sectors of energy, food/agriculture, transport, and ICT/digital. We also conducted desktop review of key activities underway in 10 other important domains, plus risk management.

Team members conducted literature reviews and academic research on GCRs and the risks of nuclear war. We examined the literature on global catastrophe, existential risks, nuclear war/winter, and approaches to mitigating these risks. The team published six relevant peer reviewed technical papers[49] during the project timeframe and we draw upon this information in this report.

The project team also published more than 20 scholarly blogs to supplement this work. These blogs are referenced throughout this report, and can be read on the Adapt Research website,[50] and among the Briefings of the Public Health Communication Centre.[51]

Webinar and Expert Panel Discussion

High-level findings of the NZCat project to date were presented at a public webinar on 25 October 2023, at which an expert panel responded to the findings and audience questions were addressed. The webinar recording is available online.[52]

Table 3: Overview of Expert Interview Participants

Sector/Organisation	Expert's role
Food/Agriculture	
Food and grocery	Senior management role
Farm holding company	Arable Farmer/Managing Director
Government primary industries	Senior scientific role
Agricultural technology	Former Chairman
Public Service	Former senior leader
Energy	
Petroleum Supplier	Asset Advisor
Government	Former senior scientific role
Transport	
Transport Planning Consultancy	Consultant Engineer
Transport Company	Chief Information Officer
ICT/digital	
Futures & Technology	Consultant
Cloud Provider	Chief Executive
Network Technologies	Business Development Manager
Economy	
Economics	Senior academic
Economic Consultancy	Founding Director
Risk & Disaster Management	
Local Government	Emergency Management Specialist
Foresight and Futures	Consultant
Urban Planning	Academic
Risk Management	Academic

Limitations

This investigator-led study had limitations that included resource constraints and the voluntary nature of contributions from half the project team, workshop attendees, and survey respondents/interviewees. The team of accomplished generalists covered a wide range of specialist content areas, which may result in some imprecision. We have made every effort to ensure accuracy but apologise in advance for any errors.

The NZCat Team engaged with dozens of experts and stakeholders, as well as official information and academic reports, but the project's scale and scope had limits, and not every perspective may have been represented. While anonymity was assured, some contributors might have been hesitant to discuss catastrophic risks candidly.

Nuclear war is inherently uncertain, yet therein lies the immense risk and it must be addressed. Nuclear war could happen tomorrow, but the likelihood is unknown to any degree of precision. The impacts beyond direct blasts and radiation are poorly understood, including the psychological, social, and economic effects. The severity of any nuclear winter is also uncertain and controversial, and the way that societies respond can't precisely be known before the fact.

As this is the 'first word' for 35 years on this topic in NZ, we stress that everything ought to be further refined and improved by additional expert groups, organisations, industries, communities, and other knowledge holders.

This report is just an initial step, and we highlight the need for additional research, analysis, and action. Ideally, the NZ Government should support this further work to reduce uncertainty, prioritise resilience initiatives in case of nuclear war/winter and enhance national well-being in the event of a global catastrophe.

PART B: Core Findings

Image credit: MidJourney

Overview of Findings Section

Part B of this report describes the main project findings, bringing together the information in the Hazard Profile, and that obtained from the workshop, qualitative survey, interview study, document reviews, and academic research conducted by the NZCat team.

Full results from the Survey, Interview Study, and webinar panel discussion, including supporting participant quotes, can be accessed as follows:

- Full survey report here:[53] [Link]
- Full interview report here:[54] [Link]
- Full webinar panel discussion here:[55] [Link]

We present the findings about the impacts, vulnerabilities, and resilience options against nuclear war, sector-by-sector, starting with four key sectors (the 'big four'), Food/Agriculture, Energy, Transport, and ICT/digital. These sectors critically underpin the functioning of NZ society, economy, and the population's ability to meet basic needs.

Each sector report starts with a one-page summary, (which we refer to as the 'Cheat Sheet') that provides an integrated overview compiled from all information sources. The 'Cheat Sheets' summarise the major impacts of nuclear war, NZ's vulnerabilities, and a range of resilience options organised into the following categories: Sector/institutional reforms, central government actions, local government actions, government investments, research and development, response plans (blue box), and co-benefits of resilience (green box). These sheets sketch the kernel of a national strategy and response plans for global catastrophe.

Each sector report also contains a section called 'Interviews and Survey' so that it is clear which concerns and resilience options were also, or additionally, suggested by expert participants.

Following the four sector reports, a fifth detailed section critiques the Risk Governance and Risk Management apparatus itself, and we present findings relevant to managing global catastrophe and nationally significant risks in some detail. We provide a summary sheet at the outset.

We follow these five sections with brief details about the vulnerability and resilience, or critical significance, of 10 other important domains, which we did not have resources to study in depth. These are: water, supply chain & external trade, industrial inputs, manufacturing, finance/economics, border issues, health & health security, social response & governance, legal & regulatory issues, Māori issues.

Although this report is organised by sector, and GCRs can be classified according to critical systems they affect,[56] we note that damage to one critical system can cascade to cause failures in others.[57] Human systems are complex adaptive systems embedded in complex ecological adaptive systems,[58] and there is potential for unpredictable cascading effects and widespread harm from GCRs (Figure 6 & Figure 7).

Figure 6: The impacts of a Northern Hemisphere nuclear war on NZ risk collapse of industry due to likely trade isolation and interdependencies among sectors

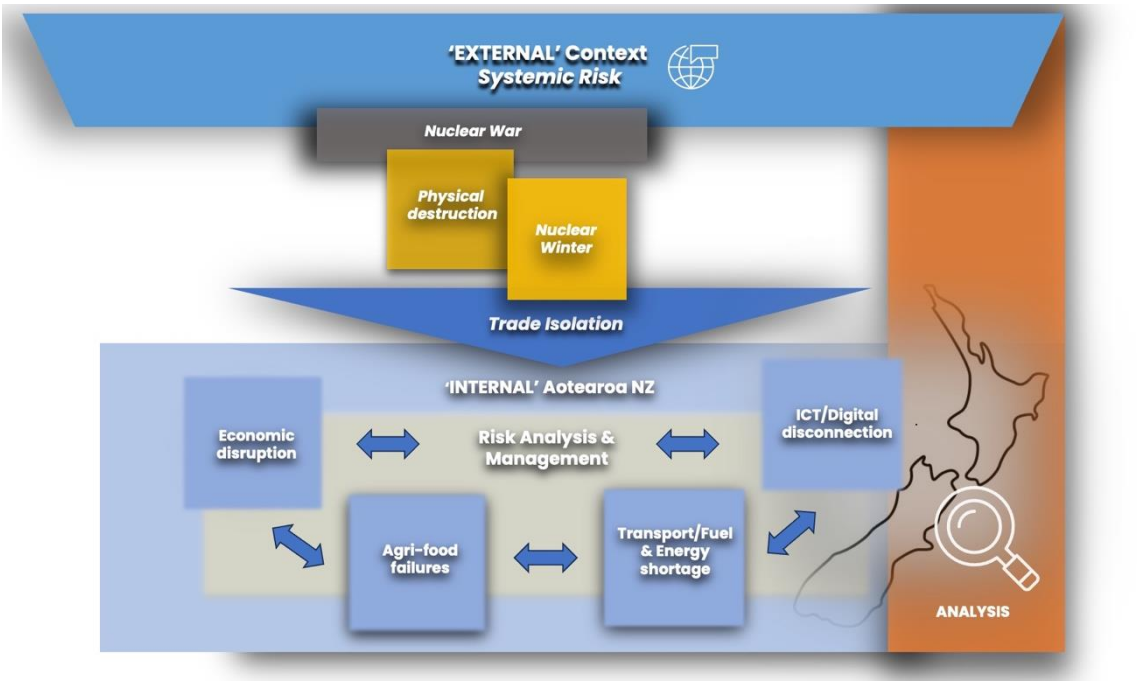
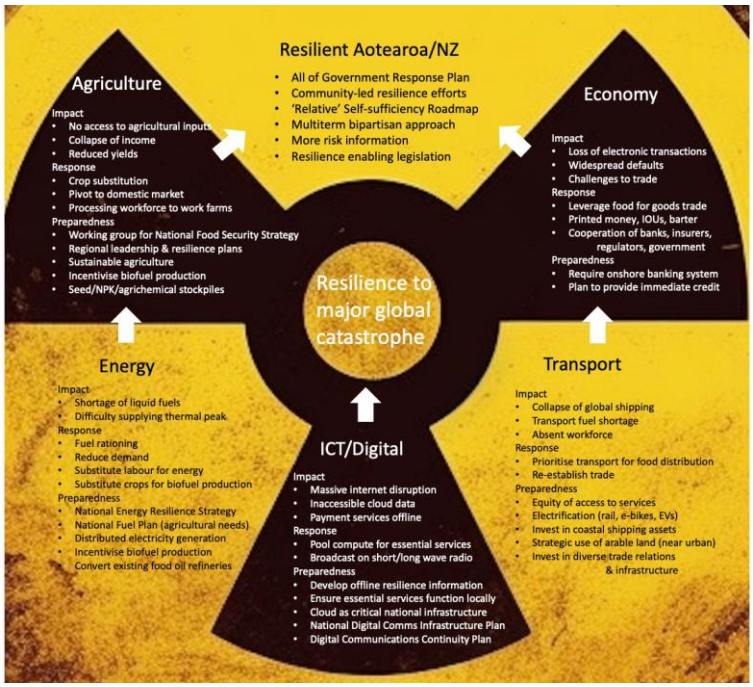


Figure 7: High-level summary of findings from the NZCat qualitative survey of nuclear war impacts and resilience options across key sectors. Note that functioning Energy, ICT/digital, and Transport sectors are essential to sustaining Agriculture and some level of Economy.



Food & Agriculture

Cheat Sheet

Nuclear War: NZ Agriculture/food resilience

Desired outcomes: A food production, processing and supply system that can provide sufficient food energy, protein, and dietary balance for the population.

Main risks of nuclear war: Breakdown in trade threatening supply of fuel for farm machinery, seed, fertiliser, agrichemicals, and other inputs to industrial agriculture; and a nuclear winter that cools the climate and reduces agricultural yield.

Resilience option: Develop a National Food Security Strategy that takes an all-hazards approach to risks impacting food supply and corresponding resilience measures.

Sector & Institutional reforms:
Shared Government-industry approach
- To food security with sector-led resilience
- Sector-wide cooperative scenarios & simulations

Increase diversity of NZ agriculture
- Reduce monocropping, increase food substitutability, local supply, dietary sourcing flexibility index, disseminate knowledge

Research & Development:
- Determine how to reduce dependence on imported agricultural inputs
- Determine logistics of supplying minimal biofuel for agricultural equipment
- Investigate resilient foods, frost resistant crops, soil protection, electrification, optimal land use, maximising marine stocks, urban agriculture, food waste reduction, rapid scale-up of resilient approaches
- Quantify NZ food production and distribution under nuclear winter and zero trade/scarce fuel conditions
- Chained modelling of nuclear winter climate perturbations and economic models
- Meaningful consultation with Māori
- Community consultations (surveys, citizen assemblies, Polis-type engagement)

Central Government Actions:
DPMC to include GCRs and agricultural production shock in nationally significant risks
Develop a National Food Security Strategy
- Nationwide all-hazards vulnerability assessment
- Include nuclear/volcanic winter & no trade scenarios
- Quantify food energy need & how to supply it
- What infrastructure is yet needed?

Provide risk information
- Integrate food security with DPMC's nationally significant risks
- Include agri-food sector impacts from GCRs in a National Risk Assessment & Risk Register

Incentivise local solutions
- biofuels, regenerative farming practices, localised production & food distribution

Collaborate with Australia
- Maximise efficiencies, reduce analytic duplication, and identify post-catastrophic Trans-Tasman trade opportunities.
- Ensure regional production of seed, and agrichemicals

Assess cost-effectiveness of resilience options
- Based on likelihood and impact of catastrophe, effectiveness of interventions, and additional co-benefits

Develop a Response Plan [See box below]:
- Fuel supply, quantities, rationing and biofuel production
- Logistics of diverting export food to domestic market
- Scale-up of frost resistant and high yield crops
- Optimise farm tooling, fertiliser and agrichemical distribution
- Herd culling, scale-down of less efficient food production
- Scale-down dairy production if liquid fuel supply constrained
- Workforce allocation and optimization
- Expand pre-industrial gardening where possible
- Food rationing guidelines
- Logistics of food supply to worse off countries

Local Government Actions:
Central Government support for local government
- Plans for sustaining local food supplies in catastrophe conditions (urban agriculture/community gardens, local farmers markets, iwi initiatives/Māori community gardens)

Government investments/infrastructure:
Sponsor community-led food resilience initiatives
Invest in considered, appropriate stockpiles
- Seed, agrichemicals, critical parts for machinery, and biocides/stabilisers for stored diesel

Invest in data & information infrastructure
- To collate/disseminate data on capital stocks, plans, resilience & response

Consider development of biorefining capacity
- To provide biodiesel in no trade scenario

Co-benefits of risk mitigation:
The resilience approaches listed above would likely
- Reduce greenhouse gas emissions
- Increase population health benefits through consuming more vegetables and fruits
- Generate commercial benefits from new industries
- Provide resilience to a wider range of natural disasters
- Reduce costs of local food supply

This section outlines the challenges and solutions the NZ food and agriculture sector might need to consider in the face of a Northern Hemisphere nuclear war, or similar global catastrophe. The NZCat expert workshop, survey, and interview participants described the potential for NZ to produce sufficient food post-crisis provided key challenges are overcome (Box 3).

Participants suggested a National Resilience Framework and National Food Security Strategy, along with considerations for labour supply, regulatory adjustments, energy alternatives, and strategies for continuing trade. Critical decisions would be required to ensure a balanced diet and appropriate food distribution. Comprehensive planning and collaboration are needed. NZ could undertake the key preparations above to reduce this risk. These points are covered in more detail in the pages that follow and in NZCat's technical papers (see Appendix).

Box 3: Resilience Nugget

Elements of a NZ Nuclear War/Winter Food Response Plan

- Ensure equitable and affordable access to food
- Ensure international collaboration (before and after) to minimise impacts globally
- Communicate with all New Zealanders, be clear solutions are possible
- Divert export food to domestic market[59]
- Replant with cold tolerant crops (and consider constructing greenhouses)
- Scale-up frost resistant and high yield crops[60]
- Expand the food crop area of efficient crops (especially near to towns)
- Implement a Fuel Supply Plan, including monitoring quantities and rationing
- Scale up biofuel production to power agricultural machines and food transport[61]
- Calculate and optimise farm tooling, fertiliser, and agrichemical distribution (rationing where needed)
- Cull herds, and scale-down less efficient food production
- Scale-down dairy production if liquid fuel supply constrained
- Divert fodder crops to human consumption
- Optimise workforce allocation for food calorie production
- Expand pre-industrial gardening where possible
- Implement food rationing guidelines
- Optimise food trade/food aid to countries where shipping remains possible
- Support development of seaweed, aquaculture, or promising industrial and resilient food

The impact of nuclear war on food & agriculture

Two key features of a likely nuclear war scenario could put severe pressure on NZ agriculture and food supply. These factors are severe disruptions to trade, and the climate effects of a possible nuclear winter. Without mitigation, the combination of nuclear winter and severely reduced global trade could push agricultural production in NZ below the level needed to feed the population.

Dependence on trade

Modern industrial agriculture is highly dependent on industrial inputs such as seed, fertiliser, liquid fuel, herbicides, pesticides, fungicides, electricity, and manufactured components. Oil and oil-derived products are critical to industrial agriculture, including food transport and processing (see the Energy section below). Natural gas is central to fabrication of most nitrogen fertiliser. The

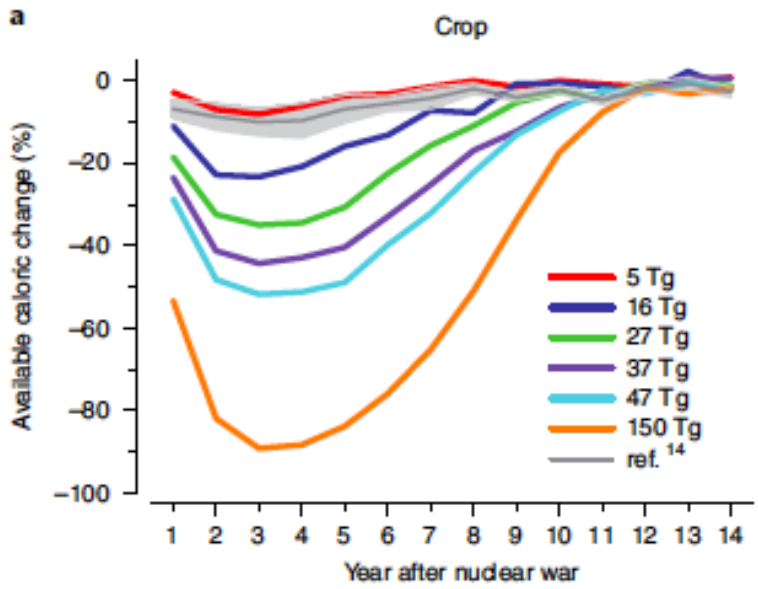
agricultural system in NZ currently consumes 295 million litres of diesel per annum, just to sustain 'off-road' processes, let alone the liquid fuel needed to move food around the country.

Agricultural production is heavily dependent on trade, and even if business-as-usual crop and fodder production continues, in the absence of trade, NZ would have more dairy and fruit than it needs, but not enough wheat to make bread. Studies have estimated that without industrial inputs crops such as wheat might exhibit a yield reduction in the order of 40% for the Oceania region, with heavily industrialised farming suffering even more.[62] While the risk may not be critical yet, growing technological dependence of farming, and the loss of backup systems, could pose challenges as agriculture increasingly relies on satellite GPS, semiconductors, and machine learning algorithms. Most real-world systems have a limited ability to return to earlier states. Equipment might be discarded, and older techniques are lost.

Nuclear winter

Soot rising into the stratosphere from nuclear firestorms could alter global climate, producing a nuclear winter that reduces crop yields (Figure 8). Recent modelling studies show that food production in NZ could fall by 8–61% in such scenarios.[63] The NZNIS Work in the 1980s identified similar concerns. In a nuclear winter, even a 1 degree C mean temperature drop might add 15−50 additional frost days in NZ.[64] However, climate impacts alone would not reduce NZ's food production below a 2,200 kcal/capita/day threshold (necessary for a healthy workforce), and diverted export dairy (eg, milk powder, cheese, and butter) could provide 132% of dietary energy requirements in the most severe nuclear winter,[65] provided the issues of trade dependence for agricultural production can be overcome (Box 4).

Figure 8: Nuclear Winter and Global (not just NZ) Famine



The relationship between the severity of a nuclear winter and the food calories available worldwide. Even a nuclear war sending 37 Tg of soot into the stratosphere could cause more than 40% reduction in global food production, causing famine, hoarding, break down in trade, and possible food conflict.[66]

Box 4: Resilience Nugget

Case Study: NZ Food Supply in Nuclear Winter

In a series of technical papers NZCat analysed NZ food exports, the impact of a nuclear winter on crop yield, the amount of liquid fuel agricultural production needs, and how yield and fuel consumption might be optimised in a nuclear winter context.

NZ food exports[67]
Current major NZ food exports are equivalent to 4 times the national dietary energy intake (34,100 kJ (8150 kcal) per person per day). Exported dairy products alone could provide 338% of the needed energy intake. Adjusting export yield for the climate impact of various nuclear winter scenarios suggests there could still be 3.6 to 1.5 times the needed food. Nevertheless, the agriculture sector could be at risk of various levels of collapse from lack of imports (eg, diesel, fertiliser, pesticides, seeds, and machinery parts) and without these industrial inputs yield would fall further, it could be difficult to transport food, and there would be less food to help neighbouring countries that might be suffering famine.

Frost resistant crops[68]
Food production might be maximised by growing more frost resistant crops. NZCat research reveals that wheat and carrots in combination, minimise the land area of agricultural activity needed to feed the population (and therefore typically minimise resource inputs). However, present production levels of these frost resistant crops are not sufficient to feed the population, and some dependence on frost sensitive crops would be needed. These frost resistant crops could be particularly efficient in a nuclear winter (but also a volcanic winter).

Fuel efficient cropping[69]
Onshore stored diesel would quickly be exhausted with ordinary use (weeks), and even with strict 90% rationing (months). To preserve fuel for agriculture, NZCat analysis found that farming wheat (requiring as little as 5.4 million litres (L) of diesel per annum to feed the equivalent of the NZ population), was more fuel-efficient than potatoes (12.3m L) or dairy (38.7m L). The wheat would require 24% of currently grain-cropped land (although this is nearly 3x the current wheat production). Under climate conditions adverse to agriculture in a worst case (severe nuclear winter) scenario, fuel requirements increased to as much as 14.7 million litres. However, this is much less than 37.5 million L for potatoes, and 107.6 million L for milk production per annum.

Biodiesel to replace refined fuel imports[70]
If growing wheat (which is both frost resistant and a liquid fuel-efficient crop), then canola seed (or some other biofuel feedstock) could be grown to produce biofuel, therefore substituting for the unavailable fossil diesel. A total of 1–7% of all currently grain-farmed land would be needed for canola. Investment in canola biodiesel or renewable diesel refineries could ensure supply for the bare minimum agricultural liquid fuel needs as an insurance policy for food production. Some expansion in refining and canola cropping before a catastrophe, as a resilience measure, might be encouraged through market mechanisms, direct government investment, or a combination of these.

Research, analysis & planning is needed
The logistics of all the above should be studied pre-catastrophe to optimise post-catastrophe response, namely scale down of dairy production, pivot of export foods to the domestic market, expansion of frost resistant crops, expansion of wheat (and other resource efficient crops) and scale up of biodiesel feedstock and refining capacity.

NZ food & agriculture vulnerability & resilience

The NZNIS in the 1980s found that the likely disruption to trade was more concerning for NZ than the climate impacts of nuclear winter. Many crops are grown from imported seed, which could be scarce. Fertilisers and trace elements like selenium, cobalt, or copper will be needed within a few years in some regions. In a nuclear winter, NZ would likely be seen as a 'food basket' by other states and there are likely stark differences in outcome between worlds that trade food and those that don't. Without an export market there would suddenly be a large quantity of frozen carcass and cheese/milk powder/butter warehoused ready for export, with need to divert it to the domestic market. This would be a logistical challenge.

Food supply issues (along with fuel rationing) are the most likely causes of social unrest. Discussions at our expert workshop in February 2023 noted that the NZ population is concentrated in urban centres, where it is not particularly self-sufficient and may struggle to access food. Indeed, some New Zealanders already suffer food insecurity regularly. A ready-made narrative about food and cooperation would be important to prepare in advance to help mitigate social tensions. Regional food resilience could be encouraged. There is considerable local work already underway that could be accelerated, for example work by the Aotearoa Circle and EatNZ. Reducing meat/dairy in favour of vegetables with less fertiliser use was also seen as good for the environment and climate generally.

Interviews & Survey

Expert interview participants contemplating the nuclear war scenario thought that even post-catastrophe NZ has the potential to produce enough food (Box 5), but a balanced diet and adequate distribution of food need to be ensured. Critical decisions would be needed about production, distribution, and substitutions to diversify and replace imported products, reallocate resources, and pivot to easily stored produce.

Post-crisis the government would likely need to intervene but needs serious expertise and good information. Expert participants advocated pre-crisis planning to identify needs and optimal locations for resources. Respondents proposed a National Resilience Framework that includes GCRs, also a set of 'zero-trade' scenario exercises and analysis of supply chains, as well as a National Food Security Strategy. This strategy would need to calculate NZ's internal food needs, and include both zero-trade, and 'no fossil diesel' scenarios, as well as account for yield losses if NPK fertiliser and agrichemicals are not available. Anticipatory scenario work is useful, but participants thought that private companies may need government support and incentives to engage. There should be shared government-industry responsibility and information sharing, with interdepartmental coordination.

Key vulnerabilities include digital infrastructure (more for distribution than production), fuel supply, as well as imported parts necessary for maintenance of equipment. The integrity of other systems like digital/mobile communications is critical (see ICT/digital section below) and again highlights the interdependencies among sectors. Modern agriculture is highly interconnected and heavily dependent on central pumped water and modern techniques. Few agrichemicals are manufactured in NZ and there are limited facilities that could be converted for manufacturing these. During the Covid-19 pandemic, some agrichemicals were flown from Melbourne. Strategies for continuing trade with Australia are needed and this could include growing grain for biofuel production to ensure shipping trade. Production of many products will have to fall, and storage of excess may be an issue.

Expert participants speculated that there could be ~20–40% yield reductions without fertiliser inputs. They mentioned that fertiliser supply is tightening globally, prices are rising, and phosphate is

limited. It was suggested that hydrogen could be used for urea production (to supplement existing production from natural gas in Taranaki). On the other hand, synthetic fertiliser-free regenerative practices might be favoured, with the result that addressing the risks posed by nuclear war might help mitigate other environmental or climate risks.

NZ could learn from other countries that maintain stockpiles (commodities like selenium, copper, and cobalt are important). Means to decrease dependence on imported fertiliser and agrichemicals should be examined, as well as analysis of seed storage and animal vaccine supply. There would be benefits from exploring reduced input regimes in collaboration with international experts in crop science. Participants suggested that plant breeding or genetic modification for frost resistance of critical crops could be explored if regulations were changed.

Although a lot of processes are automated, experts felt there was some potential to revert to manual methods, and a 'reverse roadmap' could show a way to go 'backward' from advanced agriculture to sustainable mixed farming methods in a catastrophe, in conjunction with an investment plan to build up supplies of manual tools and a coherent plan to pivot production methods. This kind of approach has been proven to work, for example in Cuba experiencing the post-Soviet collapse. Labour supply might be an issue, however, participants suggested that organisations such as the Federated Farmers and the Food and Grocery Council could coordinate labour supply across their members. However, a plan is needed.

Some regulations might need to be altered or temporarily cast aside (eg, certain food production rules, perhaps including food labelling, anti-competition legislation). Policy could be developed to strengthen food security in advance and encourage bioregionalism (based on the principle that economic and social systems are typically more sustainable when organised around naturally defined areas called bioregions). Localising food distribution would help. One example identified was that Farmers Mill is the only wheat grower that goes directly into flour production locally (Timaru), and it is cheaper to freight milling wheat from Australia to Auckland. The latter might not be possible after a catastrophe.

Survey and interview participants considered the following possible actions to mitigate risks to NZ's food and agriculture system.

- **Community- and sector-led resilience:** Create regional community-led resilience leadership structures to understand the risk, identify options, and advise on a roadmap to resilience preparedness and an overall food security strategy. A private/public partnership could fund and coordinate this planning.
- **Pre-disaster planning:** Identify options to pivot production to support domestic needs. Planning for potential large-scale disasters would help the agriculture sector respond more effectively when smaller/localised events occur.
- **Diversification of energy sources:** The sector could work towards energy diversity, potentially including the development of biodiesel capability for farm machinery operations (see section on Energy below).
- **Invest in network resilience (especially communications):** Work with telecommunications and data infrastructure providers to build greater resilience for support of essential food production and supply processes.
- **Localised food production and distribution**: The farming sector could pivot to produce a wider range of food for nearby distribution. This could involve refocusing supermarkets to rely less on imported foodstuffs and more on locally produced goods. The promotion and incentivisation of 'shop local' initiatives could improve the resilience and availability of domestic products and services.

- **Workforce mobilisation and reallocation:** In the event of widespread unemployment, the government could organise a workforce of people available to support local farming activities and community needs.
- **Resilient farming practices:** Respond with practices such as horses for transport and supply of mechanical power, decentralising livestock slaughter back onto the farm for local supply, reducing farm stocking rates to take account of lower pasture and crop production, anticipate these changes by encouraging development of permaculture and regenerative practices.
- **Transition towards a green/circular economy:** Highlighting vulnerabilities to catastrophic events could provide incentives to expedite the shift towards sustainable practices and circular economy, supported by appropriate government initiatives.
- **Optimise resource allocation:** Pool resources, machinery, and spare parts to increase efficiency, focus on high-yield production areas, and adapt crop rotations for essential food production.
- **Reduce reliance on imported materials,** including liquid fuels, and encourage innovation in renewable and compostable locally produced food packaging systems.
- **Explore alternative markets:** Identify new, and strengthen links with existing, markets in likely less-affected regions overseas (eg, Australia, Southeast Asia, and South America) to maintain trade and export opportunities.
- **Collaborate with government agencies and sector-focused organisations to invest in planning:** Improved collaboration among agencies such as the Ministry for Primary Industries (MPI), Ministry of Business Innovation and Employment (MBIE), and the National Emergency Management Agency (NEMA) and with sector focused organisations (eg, NZ Beef & Lamb, DairyNZ, Horticulture NZ, NZ Food & Grocery Council) could help map vulnerabilities (as each will see different kinds of risks) and support more resilient supply chains and improve communication security and coordination.

These measures would require significant planning and coordination within the agriculture and food sectors, as well as support from government and other sectors.

Overall, NZ needs a strategy to understand these risks and invest in enablers to support production and supply of food to the NZ market following a global catastrophe. Furthermore, a response plan for after the fact could ensure a resilient and stable food supply within NZ. Many examples mentioned in interviews also highlight co-benefits of resilience building across the suite of risks that NZ needs to mitigate, such as avoiding supply chain issues experienced during the Covid-19 pandemic.

Box 5: Resilience Nugget

NZ could produce enough food – but needs a plan and pilot projects

One expert in resilient food supply told NZCat:

- *'The big picture is that I am becoming more optimistic that NZ would be able to maintain function of most critical systems even in nuclear winter with no trade because of things like biodiesel and wood gasification. So, what might be most beneficial is if NZ could do a pilot that would be helpful to the whole world. Maybe that's repurposing a paper factory for leaf protein concentrate and cellulosic sugar production quickly. Or maybe it's doing the fast construction of hydrogen single cell protein based on the electricity that is currently going to aluminium smelting. We… need philanthropic or government money to pay for the increased cost [of a trial] due to fast construction.'*

Current agri-food risk assessment is a start but doesn't address all the issues above

A lot of existing work examining risks to agriculture and food supply, looks largely through the lens of climate change. However, it is clear from the above that the specific scenario of nuclear war/winter, and other GCRs such as volcanic winter, or synchronous global breadbasket failure, should be included in these analyses, and measures that address all risks enacted.

A 2023 cross country comparison of food resilience policies found that few governments at the national and local levels have conducted food system resilience reviews or policy planning. Economic and political crises were not generally included as food risks in national policies.[71] The report noted that NZ has indirectly addressed some aspects through climate adaptation plans, but could go further and benefit from reviewing food system resilience factors such as diversity, redundancy, connectivity, and capital reserves, while continuing to work on equity strategies.[72] Australia, Sweden, and the United States have published national-level food system resilience documents (reviews, policies, or strategies) in the last ten years.

UK analysis estimates there may be a 30% global drop in crop yields by 2050 due to climate change, with demand 50% higher.[73] There is overlap between key concerns about nuclear war and climate change and these could be addressed in concert. Literature on stockpiling food for global catastrophe generally finds stockpiling is expensive, would eventually run out, and longer term, sustainable solutions are preferred.[74]

DPMC's list of nationally significant risks includes drought, severe weather, volcanic activity, and conflict.[75] Nothing on the scale of nuclear war appears to be contemplated (nor climate altering massive volcanic eruption). It might be possible to expand these scenarios to include the risks of trade isolation and nuclear winter just described.

The MPI funded think tank Te Puna Whakaaronui identified that food production is being impacted by the consequences of the pandemic, inflation and war, rising fuel and fertiliser costs, labour shortages, as well as shipping and trade constraints.[76] Yet, there is a glaring absence of risk assessment beyond climate change in MPI's Draft Food and Beverage Industry Transformation Plan published December 2022.[77] Furthermore, not one of the 16 action points in the Draft address risks. The final form of the document stepped back altogether from such analysis.

The Aotearoa Horticultural Action Plan emphasises sustainable growing and optimising land use adaptation.[78] The NZ Lifelines Council sees agriculture/food as a secondary system, supported by critical lifelines such as water, electricity, fuel, and roads.[79] It identifies major food depots in Christchurch, Palmerston North, and Auckland as nationally significant sites. Interregional pinch points underline the need for local resilience. One limitation of the present report is that no urban agriculture experts participated in the survey or interview components of the NZCat study. Future work should address this gap.

The Aotearoa Circle has provided agricultural sector climate change scenarios and an adaptation roadmap.[80] Several of the 'physical risks' and 'transition risks' identified may be relevant to a nuclear winter scenario including yield issues, production volatility, logistics problems, pests and diseases and water insecurity. Many of the proposed solutions might also increase resilience to nuclear war/winter and this scenario could easily be contemplated in tandem. Key actions include effective land use policies, reduced reliance on animal products, and regenerative practices.

Auckland Council has advocated for national food system resilience policies, and 2023 saw a petition to Government signed by more than 70 organisations and 2000 people, calling for a NZ National Food Security Strategy.[81] Adding the impacts of nuclear winter or catastrophic trade disruption would increase the robustness of these citizen initiatives.

Image credit: MidJourney

Energy

Cheat Sheet

Nuclear War: NZ Energy resilience

Desired outcomes: Reverse NZ's trend towards decreased energy self-sufficiency and ensure adequate electrified transport/machinery and local liquid fuel production to supply essential needs in a global catastrophe.

Main risks of nuclear war: Cessation of liquid fuel imports, downturn in renewable energy production due to altered climate in nuclear winter, maintenance failures of critical centralised energy infrastructure in no trade scenario.

Resilience option: Develop a National Fuel Plan that quantifies fuel need and a rationing, distribution, and storage plan. Increase electrification and ensure sufficient electricity generation to meet demand, work to reduce demand, develop resilient distributed generation and storage networks. Develop local liquid fuel production, eg biofuels

Sector & Institutional reforms:
Shared Government-industry approach
- Consider a biofuel blend mandate
- Incentivise diverse electricity generation: solar, biomass, hydrogen, geothermal, offshore and onshore wind
- Diversify battery storage: eg mix of geothermal battery, biowaste, pumped hydro, etc (to mitigate demand peaks)

Research & Development:
- Model and quantify NZ energy production and distribution under nuclear winter climate and zero trade/scarce fuel conditions
- Fuel/electricity demand reduction (including function under radical supply restriction, eg 25% of electricity supply)
- Biofuel options (feedstock and refining processes)
- Geothermal (or other) batteries
- Meaningful consultation with Māori
- Community consultations (surveys, citizen assemblies, Polis-type engagement)

Extend the National Fuel Plan:
- Coordinate decision making across electricity, coal, gas, petroleum
- Principles of allocation based on quantity analysis of sectors and inter-dependencies
- Prioritising: (i) fuel for key governance, police, military agencies; (ii) production of key crops such as frost-resistant crops if nuclear winter; (iii) food transport; (iv) fuel for trade with Australia.
- Logistics for scaling local biofuel production to meet minimum needs (before fuel exhausted, if no preparation)

Co-benefits of risk mitigation:
The resilience approaches listed above would likely
- Reduce greenhouse gas emissions (helping the government meet climate obligations and reducing the impact of climate change)
- Improve competitive advantage (decarbonisation reduces energy risks & provides energy independence)
- Improve health through reduced air pollution, energy efficient homes, and more cycling
- Increase energy security (eg commodity shortages)
- Mitigate risk of future energy price rise resulting from cost of extraction trends
- Provide resilience to a wider range of natural disasters such as extreme weather or earthquakes (eg networks of microgrids could have helped in cyclone Gabrielle)
- Generate commercial benefits from new industries
- Inform other countries' resilience strategies

Central Government Actions:
DPMC to include GCRs and zero fuel imports in nationally significant risks
Develop a National Energy Security Strategy
- Address petroleum import dependence
- Use GCR scenarios to determine best mix of energy supply for NZ
- Explicitly contemplate extended no trade a scenario (months/years)
- Require regular cross-sector, interagency simulation/role-play of these scenarios
- Aim for reduced demand and energy efficiency
- Ensure certainty in the price of carbon
- Require audit/stocktake of maintenance, components, spare parts to guide post-catastrophe decision making and ensure maintenance in zero-trade scenario
- Regulate new builds to be energy self-sufficient/efficient where possible
- Plan for what to trade for fuel in GCR: eg food, wool, wine/beer, forestry products and possibly hydrogen (what will near neighbours want?)

Retain energy engineering expertise onshore
Incentivise widespread electrification
- EVs, agriculture, e-bikes & cycleways, additional electrified railways, electric inter-island transport eg ships/short haul flights

Provide risk information
- Include energy sector impacts from GCRs in a National Risk Assessment & Risk Register

Assess cost-effectiveness of resilience options
- Based on likelihood and impact of catastrophe, effectiveness of interventions, and additional co-benefits, be wary of stranded assets

Local Government Actions:
Central Government support for local government
- Community education on importance of renewable energy and trade-offs

Incentivise local solutions
- Reduced dependence on diesel
- Increased use of biofuels, electrification, distributed electricity generation

Government investments/infrastructure:
Stockpiles of critical maintenance parts for energy systems
Strategic fuel reserves
- Decentralized onshore stored liquid fuel and biocides/stabilisers (increase 21 days to 90 days)

Consider development of biorefining capacity
- To provide biodiesel in no trade scenario

This section outlines challenges and solutions the NZ energy sector might need to consider in the face of a Northern Hemisphere nuclear war, or similar global catastrophe. Critical decisions would be required to ensure liquid fuel supply, which might include rationing and production of fuel from alternative sources.

Interview and survey participants suggested a National Energy Security Strategy, and a revised National Fuel Plan, along with reducing dependence on imported fuel. Comprehensive planning and collaboration are needed (Box 6). NZ could undertake the above key preparations to reduce the risk from nuclear war and other GCRs. These points are covered in more detail in the pages that follow and in NZCat's technical papers (see Appendix).

Box 6: Resilience Nugget

Elements of an extended NZ National Fuel Response Plan for No-imported-fuel Scenario

Preparation for response actions:

- Assess quantity of fuel consumed by sectors over weeks, months, years
- Prioritise sector functions considering critical sector interdependencies
- Plan to implement demand reduction (by at least 90%+ in ongoing no-trade scenario)
- Identify optimal feedstock for biofuel production
- Develop capability to refine biodiesel and/or renewable diesel
- Research & prepare a plan for rapid scale up of biofuel production (identifying any resource investments needed ahead of time)
- Undertake cross-sector & interagency simulations/scenario exercises on the above

Response

- Implement strict rationing plan to optimise use of onshore fuel stocks and domestic energy production
- Implement logistics plan to scale up sowing of feedstock and biofuel production, during transition phase, to meet critical demands (eg, minimum viable agriculture)
- Ensure ongoing supply of diesel or biodiesel for essential coastal & interisland shipping, trans-Tasman trade, non-electric railway locomotives, and military/emergency uses
- Consider additional need for wood gasifiers, animal labour, or other fuel substitutes
- Ensure that fuel supply facilitates basic needs (water, food, shelter, safety) indefinitely
- Re-establish trade and seek to import fuels from Australia, Indonesia, etc (and have something of value to trade eg, food or even gold reserves)

The impact of nuclear war on NZ's energy supply

NZ energy supply is primarily sustained through continuous imports of liquid fuels, and local electricity generation and distribution, with some dependence on coal and natural gas. The 1980s NZNIS found that a major disruption to trade would bring the NZ export sector to a halt, reducing energy demand significantly. However, fuel imports might also cease, with a lack of diesel being strategically more important than a lack of petrol, because it is needed for the movement of food, manufactured goods, and fuel sources.[82]

A Northern Hemisphere nuclear war could result in disrupted supply of the energy essential for almost every modern human need. Without the ability to import fuel or parts to perform maintenance of the electrical supply there would be widespread consequences. Energy disruption

could cascade across all sectors, impeding everything from communications, to transport, payments, manufacturing, and food processing.

Diesel & other fuel

Energy is needed to run agricultural machinery and transport food. Some of this is electrical energy (eg, for irrigation systems and milking sheds), but much of the machinery uses imported diesel fuel. Substitutes for this diesel are minimal with very low levels of current biofuel production. One NZ biofuel refinery has even converted away from biodiesel production to food oil production. Furthermore, petroleum products are relatively inelastic goods, meaning that small changes in demand and supply can lead to wild price swings disproportionate to the disruption.

Strict rationing of liquid fuels might be needed, and the small quantities of biofuels prioritised for the most essential systems. Our expert workshop participants noted that for rationing to be effective there must be good information about the volumes of fuel consumed by basic services. Any National Fuel Plan should include, quantities, durations, geographic locations, and in an extended disruption, prioritise critical functions such as food production (eg, off-road farm machinery, the most efficient crops, and food transport). It must also note the dependence of fuel supply on electricity.

Box 7: Resilience Nugget

Arguments against biofuels don't apply when planning for catastrophes

Common complaints about biofuels usually relate to business-as-usual food security, or anthropogenic climate change. As soon as biofuels are mentioned some will say, 'biofuel feedstock uses finite land resources at the cost of food production' or 'using land for biofuel reduces carbon storage and doesn't guarantee carbon emissions cuts.'[83]

Yes! All very true!

However, after a catastrophe, without a supply of fossil diesel, biofuels may be *necessary* to feed large populations dependent on industrial agriculture.

A simple example illustrates the point:

Say you grow food on 10 hectares. Imagine one hectare of biofuel feedstock could produce biodiesel to run all your machinery. In normal times, you could clear an extra hectare to grow biofuel feedstock (bad – reduces carbon storage and biodiversity) or you could substitute a hectare of food with biofuel feedstock (bad – now you have less food).

Then a nuclear war hits. Liquid fuel trade is severely disrupted. You have only enough fossil diesel to run machinery on 2 hectares, and you can manually work another one hectare. The result, 70% less food and massive food insecurity. If only you could plant one hectare of biofuel feedstock and had the foresight to stockpile the seed required and to invest in refining capacity. Scaling up to one hectare of biofuel feedstock would allow you to grow food on 9 hectares, saving the population from starvation.

The standard slogans against biofuels do not apply to post-catastrophe situations. Some investment in biofuel know-how, equipment, scale-up plans, and processing capacity could save many lives and provide insurance until such time (perhaps decades away) that electrification and/or localised, low-tech, regenerative farming is widespread.

Electricity

Electricity supply would probably continue but if a nuclear winter occurred this could reduce the amount of electricity generated from renewable sources, as there could be less sunlight, less wind, and less rainfall. Although not specifically analysed in this report, the effects of an electromagnetic pulse (EMP) associated with any nuclear weapons targeting Australia could in theory disable large segments of NZ's electrical systems.[84]

The most severe potential limitation on electricity supply in NZ would likely be the disruption of global supply chains for essential components and fuels that are required to sustain power generation and distribution. Critical components could breakdown, unable to be replaced without trade. These maintenance issues would more severely impact centralised generation and distribution systems. The period of maintenance of energy infrastructure would depend on local engineering capacity. A stocktaking assessment of essential components could provide information on likely resilience.

Energy shortages are a key potential trigger of social disorder - for example through fuel or electricity being rationed without a clear and equitable plan.

NZ Energy Sector Vulnerability and Resilience

Interviews & Survey

Expert survey and interview respondents highlighted existing deficiencies in energy resilience and contingency planning. These include NZ's complete dependence on imported petrol, diesel, aviation fuel, and bunker oil for shipping. Interviewees explained NZ's reliance on refineries in the Northern Hemisphere such as in Singapore and South Korea. These refineries in turn depend on producers such as Saudi Arabia and in a conflict or crisis agreements could be reneged. NZ doesn't hold much stored fuel, and additional storage is expensive to build. Further, there is dependence of fuel supply on data servers that are based in Sydney and Los Angeles, and there is a lack of contingency planning for major technological outages.

There is a risk of disruptions to the coordination of electricity generation, and challenges in accessing crucial components and the international expertise necessary for maintaining secure supply (Box 8).

These energy sector impacts would trigger far-reaching consequences across other sectors, particularly in food production (agriculture, horticulture, and aquaculture) and transportation, which heavily rely on diesel and other liquid fuels.

There is insufficient preparation for a large-scale long-term energy/fuel crisis. Interviewees perceived a lack of government expertise in these areas and a lack of relevant long-term policies that can 'survive change in government'. There is a lack of political will to prioritise needed actions. Yet, a major event would require government intervention and use of emergency management powers, so the government is central to fuel security planning.

Enhanced electrification can reduce dependency if sufficient additional electricity supply is added. Hydrogen has also been promoted but requires costly new infrastructure to apply at scale, raising questions about its cost-competitiveness in most applications.

Biofuel production can also enhance security but faces significant barriers such as feedstock availability and competition with food supply (Box 7), cost-competitiveness, and product standards.

One expert interview participant felt government intervention would be needed for this solution to work. However, they identified that government intervention in energy and fuel can also cause unpredictable shifts in market behaviour. Biomass can be burned to provide steam power, and commercial engine designs exist, however, diesel engines are vastly more widespread.

Interviewees were clear that the National Fuel Plan needs to be extended to directly addresses trade-offs in rationed supply. There is a need to calculate how much fuel is needed, by whom, and for what, according to a population-level hierarchy of needs (and there has been limited planning so far).

Survey and interview participants proposed a range of other possible solutions to alleviate the risks to NZ's energy systems, including more investment in renewable energy and battery storage, fostering resilient and independent locally-based industries, guiding strategic direction in the energy sector, enhancing resilience of the electricity supply system, undertaking long-term supply chain planning, establishing physical repositories of knowledge to hedge against digital/electrical outage, a trade alliance with Australia for security in catastrophe, planning for food system sustainability if supply chains are broken, incorporating resilience as a major factor in economic planning, engaging key decisionmakers in GCR strategy discussions (for example, the Board of the Food and Grocery Council or Federated Farmers), and decoupling long-term planning from short-term cycles.

High-level energy resilience measures identified through the survey and interview study can be summarised as follows:

- **National Fuel Plan**: Develop a new more comprehensive national fuel plan that sets out specific rationing plans, bolsters (distributed) local fuel storage capacity, and enhances the resilience of international supply chains to meet lesser contingencies than cessation of imports. Developing a dedicated rationing plan for liquid fuels that is tailored to address the specific scenarios would be advantageous.
- **Transition to sustainable onshore transport-energy sources**: As well as ensuring diverse energy sources, the energy sector should work towards sustainable onshore transport-energy sources. This may involve electrification of heavy trucking and developing biodiesel capabilities, including for farm machinery and transportation. Additionally, considering the use of food oil (eg, canola) for biodiesel production, rather than solely for food consumption, can contribute to addressing fuel supply challenges. Transition to alternative power sources such as geothermal and wind could support the resilience of continuous energy supply, and enabling additional localised generation and on-farm hydro-electric generation could be an effective resilience measure requiring prior planning and investment.
- **Infrastructure investment**: Significant investment in transport infrastructure is needed to improve secure energy sector resilience and self-sufficiency. This could include continued investment in road and rail electrification, secure fuel reserves for resilience, and coastal shipping assets including ports. This would require planning for long-term resilience.
- **Self-sufficiency roadmap**: NZ could develop a self-sufficiency roadmap to prepare for potential isolation scenarios. This would involve examining what would be needed to survive long periods of isolation, acknowledging that standard of living would be much lower.

The government could take a multi-term, bipartisan approach to ensure resilience is promoted through consistent focus on year-on-year energy infrastructure investment and multi-sector resilience planning. These measures would require significant planning and coordination within the energy sector, as well as support from government and other sectors.

Current energy risk assessment is a start but doesn't address all the issues above

The International Energy Agency tracked NZ's decreasing total energy self-sufficiency from 92% in 2010 to 76% in 2018.[85] There is a lot of existing work examining risks to energy in NZ, though largely through the lens of climate emissions. However, climate emissions reductions and improved energy resilience are so interdependent that they should be developed side-by-side. There are many risks to future global energy supply, and increasing NZ energy security would also help mitigate price shocks and supply shortfalls.

A biofuel blend mandate was considered for NZ, but in February 2023, the Prime Minister Rt Hon Chris Hipkins announced that the biofuels obligation would be discontinued.[86] However, a mechanism to stimulate local biofuel production would also assist resilience. A mechanism that assisted biofuel production could provide biodiesel, and potentially bunker fuel for shipping, the fishing industry, and appropriate biofuel for the military, including the army, navy, and air force (the United States Navy has a biofuel mix strategy).

Box 8

Critical Failures of the Cook Strait Electricity Cable 2000–2023

- 2004 – In January, three HVDC towers collapsed from extreme winds. In October, a fault occurred reducing the Pole 1 capacity from 540 MW to 386 MW. Repairs took almost six months.
- 2006 – Unplanned outage just before the evening peak period on one of the coldest days of the year. The North Island experienced electricity shortages and a nationwide Grid Emergency.
- 2008 – A transmission tower buckled after its foundations slipped. The tower was reinforced with steel guy ropes until it could be replaced, as the link couldn't be shut down without causing widespread power shortages in the South Island.
- 2013 – During the commissioning of the new two-pole control systems, a test led to the HVDC controls automatically cutting northbound transfer from 1000 MW to 140 MW, blacking out thousands of customers. A software bug was found to be the cause of the filter bank trips.
- 2021 – The HVDC transmission line failed near Weka Pass, leading to a Grid Emergency Notice. Severe weather conditions delayed the repair and the return to service.

The lesson is that critical energy infrastructure can fail, centralised systems are fallible, and in the context of disruption to imports or digital systems, repair may not be forthcoming.

The NZ Infrastructure Commission outlined the 'State of Play' for energy in 2021.[87] The report noted worsening trends in NZ's energy import dependence, the diversity of electricity generation, and energy storage. This is despite NZ's fuels, transportation, telecommunications, and water infrastructure being dependent on reliable energy services. Major asset risks identified included the Cook Strait high voltage direct-current (HVDC) electricity cable (Box 8), Marsden Point liquid fuel importing infrastructure, onshore and offshore oil stocks, and hydro storage. There is some redundancy in the electricity sector, with standby generation able to cover failure of the largest (transmission or generation) single asset. Electricity generation is primarily centrally dispatched but there is also some distributed generation (along with storage totalling 114 MW). Electricity generation has been largely stable, but there is a dry year risk. Mass electrification (eg, of transport) is likely to take decades. NZ's gas and oil pipelines need maintaining and recent failures illustrate this. Geothermal energy could be expanded but is hindered by complex consenting/protection issues. The

report also notes that 'Green' hydrogen has been gaining momentum, but questions remain about its role in the NZ energy market.

Overall, there is some movement of the energy sector towards increased resilience. However, key aspects of GCR scenarios are not fully addressed. These include scenarios where petroleum imports are unavailable for extended periods, and scenarios where major infrastructure fails but commodities and expertise for maintenance and repair are unavailable. There may be need to pursue inefficient solutions because they develop resilience against global catastrophe.

DPMC's list of nationally significant risks includes critical infrastructure failure, energy price shock, and major trade disruption.[88] However, nothing on the scale of a GCR appears to be contemplated.

Government policies on fuel storage: NZ no longer refines crude oil locally and the Government introduced a fuel resiliency policy package in 2022.[89] Fuel importers and wholesalers with bulk storage facilities will be required to hold minimum levels of onshore stocks of petrol, jet fuel, and diesel. Minimum fuel stockholding levels for them will equate to approximately 28, 24 and 21 days' worth of petrol, jet fuel and diesel respectively. The Government will procure an extra 7 days' diesel storage. Following a catastrophe, onshore fuel reserves need to be adequate for an extended period of transition to new ways of operating and the proposed minimum storage requirements don't significantly improve the situation (Table 4).

Table 4: NZ onshore fuel stockholdings have barely changed despite a new Fuel Resilience Act[90]

	Diesel (days cover)	**Petrol (days cover)**	**Jet Fuel (days cover)**
Before Marsden Point Refinery closure	25	31	22
After Refinery closure (MBIE expected)	21	28	24
Minimum holdings required by Fuel Industry (Improving Fuel Resilience) Amendment Act 2023	21	28	24
Change from before Refinery closure	-4	-3	+2
NZ Government planned stockholding	7	-	-
Total change from before Refinery closure	+3	-3	+2

Additionally, government policy on how much fuel to store onshore, are based in part on a 2017 risk assessment that contemplates a worst case of a 10% reduction in global crude oil supply, for just 6 months. The assessment assumes a 2.5% annual probability of that scenario.[91] This low-level interruption scenario does not provide a sufficient challenge to resilience in the face of a global catastrophic risk. A full cost-benefit analysis that systematically includes the likelihood and consequences of the range of GCRs would be useful. **A further risk assessment was commissioned in 2020 to contemplate the effects of a potential closure of the Marsden Refinery**,[92] yet this study also assumed flexible global trading capabilities persist and skirted the issue of a major global catastrophe (such as Northern Hemisphere nuclear war) destroying, not merely disrupting supply. The authors write:

> 'Where the loss of refining capacity could impact NZ is if there was a failure in normal global trading activity. Such an event is beyond the scope of any scenarios modelled. In this case the loss of crude/refinery intermediate stock would reduce NZ's options as would the loss of the ability to at least refine NZ's domestic crude. We acknowledge that in such circumstances other import dependences may be more critical than fuel, and as shown in the Covid-19 response, fuel use can be dramatically reduced if necessary.'[93]

The authors noted that, 'Companies were unwilling to speculate on the impact of such an event during the consultations,' making analysis difficult. However, their assumption that 'other import dependencies may be more critical' is surprising, given the total reliance of NZ industry (and food production) for imports to meet their liquid fuel needs. Indeed, liquid fuel shortages were the most common concern across expert responses in our NZCat workshop, survey, and interview studies.

NZ needs a Resilience Plan for Transport Services that is framed by looking at all the fuel options – especially electricity and biofuels – along with petroleum imports and stocks.

CDEM NZ Fuel Supply Plan:[94] The present National Fuel Plan provides a framework for rationing available fuel stocks in an emergency. However, increasing supply would be difficult in the absence of trade and the list of critical customers does not make clear whether agricultural production machinery and other certain important users are 'critical'.

The plan says little about how fuels will be rationed and gives no indication of the rate at which fuel should be rationed. It identifies the Marsden point import jetty as being in a tsunami zone, with facilities there dependent on electricity for operation, and also associated pipeline risks. This suggests, even if trade is possible, there are other serious risks to fuel supply that need to be better accounted for. There is much room for improvement of this plan.

NZCat calculated how much liquid fuel current industrial agriculture would require to produce enough food to feed the NZ population if focusing on high per-hectare yield crops, such as wheat and potatoes, when compared to milk production (Box 9). It turns out that substantial volumes of fuel can be conserved with a pivot to increased wheat production. This fuel could in theory be supplied by converting a small amount of grain-cropped land to produce biofuel feedstock along with appropriate biodiesel or renewable diesel refining capacity.

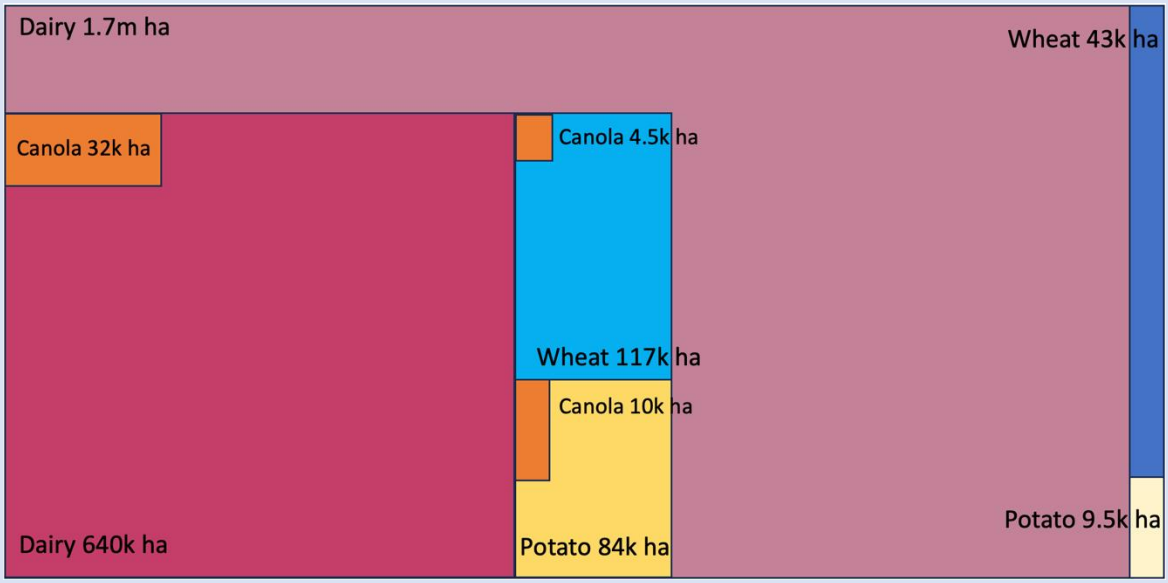
Parliamentary Commissioner for the Environment supports an Energy Strategy: The PCE wrote to the Minister for Energy in December 2022, supporting the development of a whole-of-system Energy Strategy.[95] But the PCE criticised the time taken, and the degree of input from commercial interests. Speedy, 'low regrets', options might include new electricity distribution and transmission infrastructure, smart electricity infrastructure, and flexible multi-directional flow infrastructure. Storage options should be analysed and stress-tested using scenarios and a whole-of-energy-system lens. We suggest that such scenario testing should include scenarios from our nuclear war Hazard Profile and other GCRs.

Transpower reported in 2021 on opportunities and challenges in the electricity sector, providing some evidence that the electricity industry is anticipating future problems, has a range of ideas, and looks to be shifting to a more resilient model.[96] The report highlighted that increased reliance on digital services, and electricity sector coupling to transport, are important changes.

However, regulation currently does not allow for electricity sharing, and regulatory reform allowing solar electricity, for example, generated by house A to be shared with house B, or C, could improve resilience against the kinds of disruptions experienced during Cyclone Gabrielle, but also other kinds of catastrophes.

Box 9: Resilience Nugget

Prioritising land use to conserve liquid fuel[97]

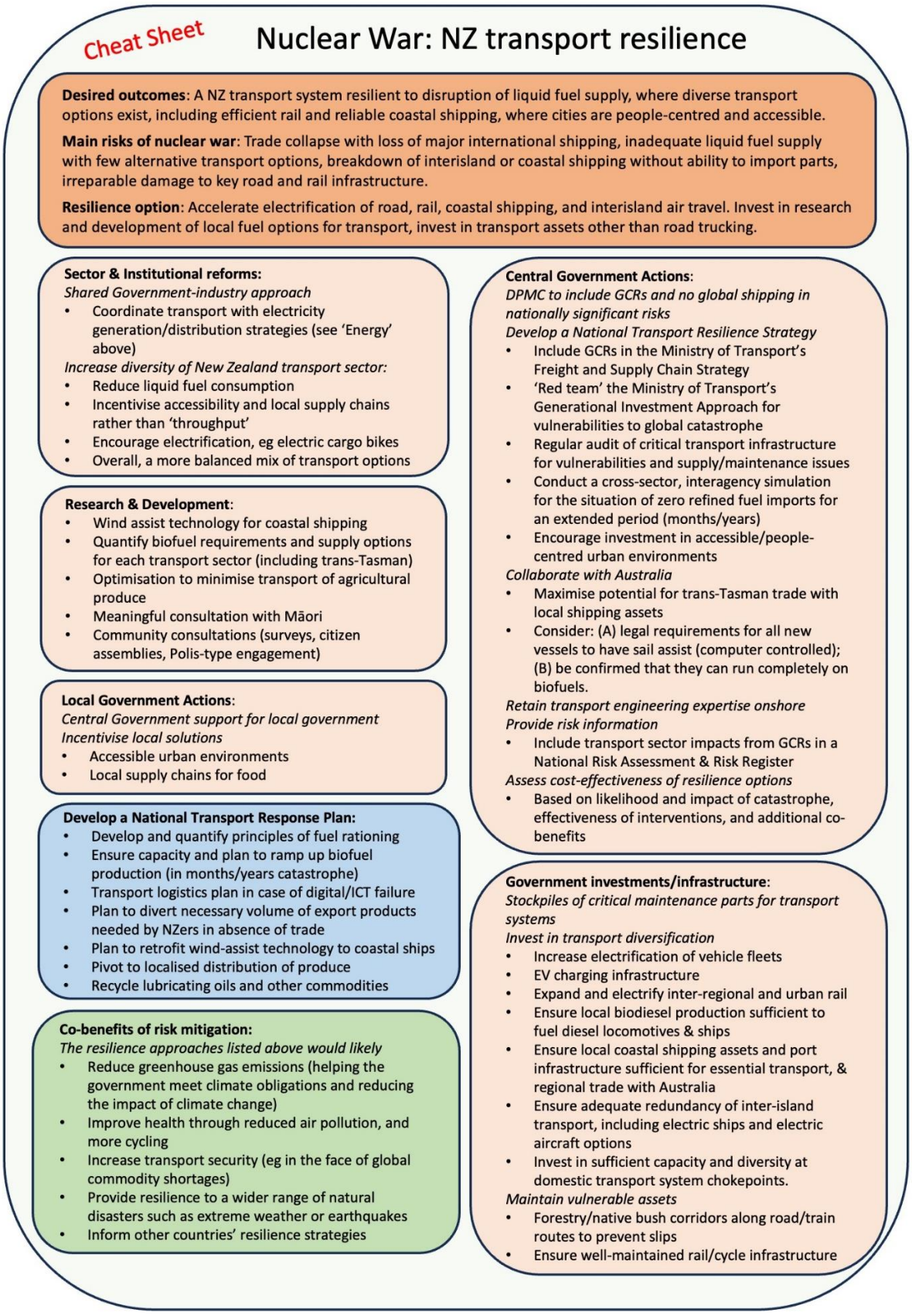


NZCat analysis found that prioritising wheat production could supply NZ's food calorie needs, while minimising biofuel scale-up needed to run agricultural machinery in an extended 'no imported fuel' scenario.

In the figure above the outer rectangle represents current NZ production (including exports) for dairy (1.7 million hectares), wheat (43,000 ha), and potatoes (9,500 ha). While the inner rectangle represents the land area needed to supply food calories for the NZ population if using dairy (640,000 ha), OR wheat (117,000 ha), OR potato (84,000 ha). Notably, wheat is the most liquid fuel-efficient approach and biodiesel from just 4,500 ha of cropped canola could fuel the needed level of wheat production (orange squares).

The message is that in an ongoing low-fuel import or no-fuel import catastrophe, agricultural activities such as dairy production should be wound down, and wheat production and other crops with favourable food energy to liquid fuel ratios should be scaled up. Some preparation to enable this transition, if needed, should be considered from a risk management perspective.

Transport


Cheat Sheet
Nuclear War: NZ transport resilience
Desired outcomes: A NZ transport system resilient to disruption of liquid fuel supply, where diverse transport options exist, including efficient rail and reliable coastal shipping, where cities are people-centred and accessible.
Main risks of nuclear war: Trade collapse with loss of major international shipping, inadequate liquid fuel supply with few alternative transport options, breakdown of interisland or coastal shipping without ability to import parts, irreparable damage to key road and rail infrastructure.
Resilience option: Accelerate electrification of road, rail, coastal shipping, and interisland air travel. Invest in research and development of local fuel options for transport, invest in transport assets other than road trucking.
Sector & Institutional reforms:
Shared Government-industry approach
• Coordinate transport with electricity generation/distribution strategies (see 'Energy' above)
Increase diversity of New Zealand transport sector:
• Reduce liquid fuel consumption
• Incentivise accessibility and local supply chains rather than 'throughput'
• Encourage electrification, eg electric cargo bikes
• Overall, a more balanced mix of transport options
Research & Development:
• Wind assist technology for coastal shipping
• Quantify biofuel requirements and supply options for each transport sector (including trans-Tasman)
• Optimisation to minimise transport of agricultural produce
• Meaningful consultation with Māori
• Community consultations (surveys, citizen assemblies, Polis-type engagement)
Local Government Actions:
Central Government support for local government
Incentivise local solutions
• Accessible urban environments
• Local supply chains for food
Develop a National Transport Response Plan:
• Develop and quantify principles of fuel rationing
• Ensure capacity and plan to ramp up biofuel production (in months/years catastrophe)
• Transport logistics plan in case of digital/ICT failure
• Plan to divert necessary volume of export products needed by NZers in absence of trade
• Plan to retrofit wind-assist technology to coastal ships
• Pivot to localised distribution of produce
• Recycle lubricating oils and other commodities
Co-benefits of risk mitigation:
The resilience approaches listed above would likely
• Reduce greenhouse gas emissions (helping the government meet climate obligations and reducing the impact of climate change)
• Improve health through reduced air pollution, and more cycling
• Increase transport security (eg in the face of global commodity shortages)
• Provide resilience to a wider range of natural disasters such as extreme weather or earthquakes
• Inform other countries' resilience strategies
Central Government Actions:
DPMC to include GCRs and no global shipping in nationally significant risks
Develop a National Transport Resilience Strategy
• Include GCRs in the Ministry of Transport's Freight and Supply Chain Strategy
• 'Red team' the Ministry of Transport's Generational Investment Approach for vulnerabilities to global catastrophe
• Regular audit of critical transport infrastructure for vulnerabilities and supply/maintenance issues
• Conduct a cross-sector, interagency simulation for the situation of zero refined fuel imports for an extended period (months/years)
• Encourage investment in accessible/people-centred urban environments
Collaborate with Australia
• Maximise potential for trans-Tasman trade with local shipping assets
• Consider: (A) legal requirements for all new vessels to have sail assist (computer controlled); (B) be confirmed that they can run completely on biofuels.
Retain transport engineering expertise onshore
Provide risk information
• Include transport sector impacts from GCRs in a National Risk Assessment & Risk Register
Assess cost-effectiveness of resilience options
• Based on likelihood and impact of catastrophe, effectiveness of interventions, and additional co-benefits
Government investments/infrastructure:
Stockpiles of critical maintenance parts for transport systems
Invest in transport diversification
• Increase electrification of vehicle fleets
• EV charging infrastructure
• Expand and electrify inter-regional and urban rail
• Ensure local biodiesel production sufficient to fuel diesel locomotives & ships
• Ensure local coastal shipping assets and port infrastructure sufficient for essential transport, & regional trade with Australia
• Ensure adequate redundancy of inter-island transport, including electric ships and electric aircraft options
• Invest in sufficient capacity and diversity at domestic transport system chokepoints.
Maintain vulnerable assets
• Forestry/native bush corridors along road/train routes to prevent slips
• Ensure well-maintained rail/cycle infrastructure

This section outlines challenges and solutions the NZ transport sector might need to consider due to the risk of a Northern Hemisphere nuclear war, or similar global catastrophe. Liquid fuel supply for transport is critical and its disruption was discussed under 'Energy' above. Alternatives to diesel-powered road trucking need to be available. Other transport modalities also depend on liquid fuels. Loss of global shipping would seriously impact the supply and distribution of goods around NZ.

Rail and coastal shipping can be enhanced, as well as electrified transport options. However, recent neglect of rail and the dearth of coastal shipping assets, along with reliability issues plaguing interisland ferries, indicate that significant investment may be required to achieve adequate alternatives to road.

Additional approaches include running scenarios and red-teaming (rigorously challenging with an adversarial approach) current transport system resilience, **developing additional rationing principles for fuel, increasing transport system diversity and redundancy, auditing transport infrastructure, investing in resilience, and researching alternative energy sources for transport**. Comprehensive planning and collaboration are needed because transport critically underpins agricultural production, and the distribution of fuel, commodities, and workforce.

Based on our research and data collection, NZ could undertake the key preparations presented above to reduce the risk from nuclear war and other GCRs. These points are covered in more detail in the pages that follow and in NZCat's technical papers (see Appendix).

The impact of nuclear war on NZ's transport system

Nuclear war could cause major disruption to global transportation, including to international freight and supply chains, **with potential destruction, not just disruption, of the underpinning infrastructure**, as well as conflict, national hoarding, and piracy. NZ could be disconnected from global air and shipping routes (the latter account for 99% of trade by volume). This could prevent fuel arriving in NZ, crippling NZ's heavy reliance on road freight (accounting for 93% of national freight volume) (Figure 9).

NZ's geographical isolation and island configuration mean it has comparatively few air connections to the world and is dependent on interisland shipping. In the 1980s, the NZNIS reported a mere 16 vessels in the coastal shipping fleet. Today, while there are around 13 vessels serving coastal shipping routes, only one is a container ship. The post-pandemic recovery of the country's supply chain lagged the global average, as illustrated by Maersk's decision to halt its NZ coastal service shortly after its launch, urging an overhaul of the supply chain. Furthermore, the Cook Strait ferries have been plagued by disruptions due to an aging fleet. Delays in this service have caused ripple effects, impacting the movement of goods and escalating costs.

Meanwhile, road transportation is the largest energy consumer in NZ and still has an overwhelming reliance on imported refined fuel. The government's draft electric vehicle (EV) charging strategy released in March 2023 signals a shift towards sustainable road transport, but the country's low electric vehicle fleet percentage, combined with the absence of an extensive rail network and the demands of transporting goods like milk daily, mean at present there are major vulnerabilities in the system. Shipping, rail, and air transport also require liquid fuel, and although rail is second to road by freight volumes it still accounts for less than 6%.

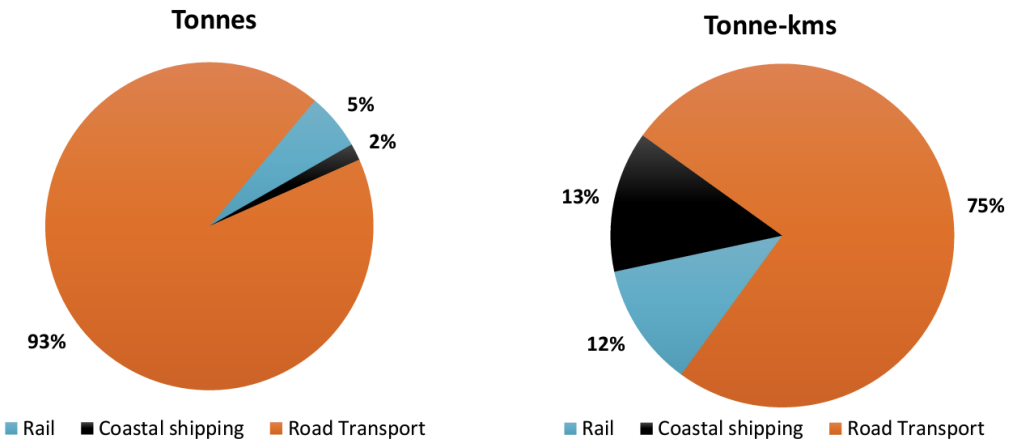
Without access to global shipping, transport maintenance issues would arise, for example the lack of lubricating oils would be a major problem for cars, trucks, tractors, ships, planes, and trains. Rail

and shipping are more fuel-efficient than road, but there would be a need for many more small local shipping units, access to ports, and sufficient containers to carry goods, along with local sources of fuel.

A severe disruption in transportation could lead to a domino effect across all sectors. Agriculture, food distribution, commodity supply, and workforce mobility would be gravely affected. NZCat workshop participants speculated that an economy devoid of transport and fossil fuels might see a contraction of more than half. In extreme cases, regions could face de-industrialisation due to inadequate transportation. It's worth noting that even in regular circumstances, NZ's lack of transport route redundancies has made it susceptible to natural disasters like Cyclone Gabrielle and the Kaikoura earthquake. Such vulnerabilities could be magnified post a nuclear conflict.

NZ's transport infrastructure, cargo fleets, and energy sources must be robust enough to withstand trade isolation, especially when considering the production and distribution of food. The nation currently faces an infrastructure investment deficit estimated at NZ$100 billion.[98] Addressing this shortfall necessitates strategies that not only fulfil immediate transport requirements but also offer resilience against global catastrophes.

Figure 9: Almost all movement of commodities in NZ is by road trucking[99]



	Tonnes		Tonne-kms	
Mode	Million Tonnes	Per cent of total	Billion tonne-kms	Per cent of total
Rail	15.6	0.056	3.5	0.115
Coastal shipping	4.6	0.016	4	0.134
Road Transport	258.5	0.928	22.6	0.751
Total	278.7	1	30.1	1

NZ Transport Vulnerability and Resilience

Interviews & Survey

Expert survey and interview respondents confirmed that NZ's supply chain is heavily dependent on road trucking, but also functioning digital and IT systems. Participants noted the lack of local shipping capacity (capacity could be enhanced with more coastal ships). NZ could develop more local manufacturing options to provide resilience, including mineral sources for batteries. This could include latent capacity for local production to access in times of need. It was suggested that

KiwiSaver funds could be used to boost local industry, and that NZ should look to retain its manufacturing and transport talent.

Shifting to more localised supply chains (eg, seasonal vegetables, and reduced expectations for 'always available') would help transport resilience. A transport strategy should focus on a minimum level of resilience. Senior transport leadership team conversations could include resilience, with a shift to anticipating/planning for a wider class of risks, and dedicated personnel that solely focus on resilience.

Interviewees felt that transport in NZ needs to become less dependent on oil and more diversified and joined-up with local transportation hubs, electrification, design for ease of access, and 'people-oriented cities' (footpaths, rail, cargo bikes, E-trucks). There should be less focus on peak-hour throughputs and more focus on resilient mobility to improve accessibility and participation. This is especially the case given the challenges of ensuring a reliable supply of liquid fuels (see above). Hydrogen (or hybrid hydrogen-diesel trucks) was mentioned and could be pursued to increase self-reliance in transport. NZ should look to act as a 'self-sufficient hub' with sufficient energy generation and data independence (see ICT/digital below).

Experts identified important interconnections between transport, mobility, community, democracy, transparency, and trust. Interviewees thought that developing transport infrastructure might require subsidising electrified public and shared transport, including electrifying inter-regional rail and the use of mobility hubs that would reduce transport needs if they included service centres, libraries, medical facilities and so on.

High-level transport resilience measures identified through the survey and interview study can be summarised as follows:

- **Crisis management planning:** Implement detailed crisis management planning that provides devolved powers to local government (Councils) who can mobilise and empower the community to address and prioritise needs. Collaborate closely across all transport sectors (maritime, rail, road, air, and logistics) to establish coordinated plans and ensure smooth flow of essential goods.
- **Prioritise fuel reserves for critical operations:** Planning is needed to manage and allocate resources effectively. Give priority to rail, truck, and maritime freight to transport essential supplies in a disrupted environment.
- **Form collaborative partnerships**: Local and regional government bodies to collaborate with the rural food production sector, and the transport sector to foster the advancement of localised food production and optimise food transport planning.
- **Infrastructure investment to reduce fuel dependency:**
    - Increase the use of bikes and e-bikes in the community to reduce reliance on transport fuels.
    - Increase the capacity of trains to take bikes and increase access for bikes and e-bikes within urban environments.
    - Facilitate longer-distance travel without the need for personal vehicles, with an overall transition to reducing nation-wide car dependency.
    - Further investigate the use of electric planes on short routes, such as interisland transport.
    - Investigate alternative power sources for transport such as advanced steam technology.
- **Enhance coastal shipping operations and port Infrastructure:** Coastal shipping can provide material connectivity and could be powered by renewable energy (biofuels or electricity).

This is a priority area for action as unfortunately present efforts to resuscitate coastal shipping are foundering.[100]

- **Local food production:** Strengthen local production and supply chains, reducing reliance on international sources and fostering resilience. Require regional councils to plan for the provision of sufficient local production of food, and transport of that food to sustain the population of the region, including protection of needed horticultural land from urban development.

These actions would require a coordinated and adaptive response from various stakeholders and sectors to tackle the significant challenges posed by the nuclear war scenario. With specific emphasis on urban transport, respondents emphasised that resilience measures would require a shift from a car-centric 'freedom of mobility' design focus to a community-centric 'equity of access' approach, which largely fits with some current NZ initiatives in urban transport planning. The transport sector could potentially organise itself to deliver community-centric access, connecting across organisations that would need to know how each other operates, and setting up lifeline and support systems.

Current transport risk assessment is a start but doesn't address all the issues above

In general, current policies that heavily favour increased road building relative to other transport modalities tend to lock-in dependence on road transport and reduce resilience to major transport disruptions, including GCRs.

A report in 2015 identified 'lessons from Ebola' and concluded that there was a low level of awareness and preparedness in NZ for freight and supply chain disruption.[101] Most focus was on the risk to suppliers, rather than critical transport infrastructure. This report recommended increasing knowledge of these risks, developing more effective tools to monitor progress, and mapping existing approaches to a variety of events, with long-term consequences, and second-level impacts.

The NZ Infrastructure Commission produced a transport 'State of Play' report in 2021.[102] The report describes NZ's transport system but notes that NZ has one of the lowest inland transport infrastructure investments per GDP in the OECD. Also, that the 'run down' state of rail infrastructure constrains what can be carried, and demand outstrips supply. The report suggested the need for capital investment, long-term planning that takes a mode-neutral approach, improvements to the relationship between transport and land use, and more low-carbon modes.

The Ministry of Transport initiated a freight and supply chain consultation, based on an issues paper,[103] and developed a Freight and Supply Chain Strategy.[104] The Issues Paper focused on the impacts of climate change and the need to reduce transport emissions, growing population, technological change, and international developments. Extreme weather will damage transport infrastructure, fuel prices are rising, food miles should be reduced, renewable energy is critical, coastal shipping and rail have the lowest emissions, but infrastructure is lacking. Population growth is putting pressure on freight corridors. There is presently insufficient capacity to switch freight modes. The NZCat team's submission recommended GCR scenarios be considered as key transport issues.

The NZ Freight and Supply Chain Strategy[105] provides 30-year, 10-year, and 3-year goals. Long-term resilience and national interest are to the fore. Over 10-years the Government and the sector aim to be aware of threats to supply chain and be ready to respond. Over a 3-year period the aim is to improve domestic ports/shipping/connections, to start to decarbonise road freight, and to collaborate with international partners to mitigate disruptions. These aims would be consistent with development of a National Risk Assessment, a global catastrophe transport response plan, and strategic investments in transport diversification and resilience, as detailed here.

The Productivity Commission published an Economic Resilience Issues Paper in 2023,[106] which acknowledges that supply chain disruption will continue due to geopolitical, environmental, social, infrastructural, and health risks. It is government's role to, 'develop and protect the physical and social infrastructure underpinning supply chains.' The Commission noted the importance of medium-term adaptation. We need to 'understand' shocks, and the Commission pointed to proactive work in the United States (eg, on bringing industries back within its borders, 'reshoring') and Australia (identifying import vulnerabilities). The Commission plans to undertake economic modelling and commissioned Motu for some stages of this, and the NZCat team proposed that such modelling should incorporate zero-trade or zero-fuel scenarios. Again, the emphasis on understanding is consistent with undertaking a National Risk Assessment that includes GCRs.

NZCat's 12 recommendations to the Productivity Commission were as follows (note that these generalise beyond transport and supply chain):

1. Include global catastrophic risks in National Risk Assessments.
2. Replicate the 2022 US Global Catastrophic Risk Management Act.
3. Prepare strategies and plans to ensure food security under circumstances of global catastrophe and/or trade isolation.
4. Conduct interagency/multi-sector scenario-based simulation to explore the impact and response of NZ to major global catastrophes.
5. Red-team the above exercises and include scenarios where NZ is isolated from global trade for an extended period.
6. Introduce a new National Science Mission to study global catastrophes.
7. Conduct analysis of risk and response, provide data and information that industries and communities can use to make decisions about adaptation.
8. Support industries and communities to produce commodities that local export markets (eg, Australia) will likely need, to hedge against the collapse of long-distance trade.
9. Develop a plan to keep domestic and local regional trade and supply operating.
10. Nurture a global catastrophic risk think tank based in NZ.
11. Undertake rapid cost-effectiveness analyses across a suite of potential mitigation measures.
12. Ensure that the above analysis is conducted at national level, but also identifies regional variation in capabilities and needs.

Image credit: MidJourney

ICT & Digital

Cheat Sheet

Nuclear War: NZ ICT/Digital resilience

Desired outcomes: Digital systems in Aotearoa NZ that are resilient to catastrophic events overseas, continue to operate locally, and support NZ's economy and society without excessive dependence on international providers.

Main risks of nuclear war: Failure of overseas digital infrastructure providers, severance of connectivity to global internet, and the challenge of NZ digital/ICT infrastructure maintenance in the absence of global trade, with resultant inability to share crisis information or transact locally in NZ.

Resilience option: Develop a Digital Communications Continuity Plan, invest in local NZ digital infrastructure, including cloud services, expertise, and conduct scenario testing for loss of global connectivity.

Sector & Institutional reforms:
Shared Government-industry approach
- Classify cloud infrastructure as critical national infrastructure
- Appoint a National Chief Technology Advisor
- Leverage a National Technology Investment Agency to activate NZ's digital strategy, procure and develop appropriate technology.
- Change procurement rules to encourage local solutions (rather than dependence on foreign big tech)
- Diversify provision of cloud storage (including government data for core functions)

Research & Development:
- Innovative and resilient layers of public communication (eg local Wifi/microwave/communications balloons)
- Alternative information storage and access options (eg physical information repositories, local LLMs running offline, substitutes for digital knowledge)

Develop a National Digital Communications Continuity Plan:
- Include a scenario with full loss of global connectivity (& the impacts of an electromagnetic pulse)
- Plan & test to ensure functional national internet services if isolated from global connections
- Include a Reserve Bank Plan for No Digital Payments
- Plan to communicate risk information to public without ICT/Digital systems
- Ensure the widespread ability to receive radio broadcasts
- Ensure devolved regional ability to communicate if national capacity is impaired
- Ensure rural connectivity to maintain coordination of food supply
- Activate unmanned aircraft communications network
- 'Nowcast' information about radioactivity, climate, fuel, food, etc. To maintain the public's situation awareness and assure people there is a plan

Co-benefits of risk mitigation:
The resilience approaches listed above would likely
- Stimulate NZ businesses and economic activity
- Lessen dependence on major US providers (increasing data sovereignty)
- Improve rural connectivity, which is already a focus of the NZ Digital Strategy
- Provide an enhanced digital context for rural business
- Develop local NZ knowledge and expertise in digital/cloud/communications solutions

Central Government Actions:
DPMC to include GCRs and total loss of connectivity in nationally significant risks
Develop a National ICT/Digital Resilience Strategy
- Include GCR scenarios with global connectivity loss in risk planning
- Reduce critical dependence on overseas systems
- Develop a 3rd communication channel to supplement fibre and satellite
- Ensure regular audit of the condition of digital/ICT assets and where maintenance depends on international commodities
- Require regular audit, testing, and continuous evaluation of digital, cloud computing, and critical communications infrastructure
- Include testing of disconnection from global cloud/internet/connectivity, and assess impact this has on transport, agriculture, energy, economy and other sectors
- Ensure generator fuel supply for critical digital/ICT is addressed in a National Fuel Plan

Retain ICT/Digital engineering expertise onshore
Provide risk information
- Include ICT/Digital sector impacts from GCRs in a National Risk Assessment & Risk Register

Assess cost-effectiveness of resilience options
- Based on likelihood and impact of catastrophe, effectiveness of interventions, and additional co-benefits

Local Government Actions:
Central Government support for local government
Incentivise local solutions
- Local communications backup systems
- Ensure local failover if national systems degraded

Government investments/infrastructure:
Stockpiles of critical maintenance parts for ICT/Digital systems
Invest in diversity of NZ ICT/digital systems
- Invest in standalone local cloud and data capability
- Strategically place critical data centres in both the North and South Islands
- Invest in digital connectivity redundancy

Create offline physical knowledge repositories (eg, collocated with libraries)

This section outlines the challenges and solutions the NZ ICT/digital sector might need to consider in the face of a Northern Hemisphere nuclear war, or similar global catastrophe. The NZCat expert workshop, survey, and interview participants described systemic risks and catastrophic outcomes should digital systems fail.

Critical vulnerabilities in the ICT/digital sector include the limited number of connecting routes to offshore infrastructure, the reliance on offshore cloud service providers, the challenge of systems maintenance during trade isolation, and limited domestic backup. Given the immense dependency of all other sectors, including food, energy, and transport, on digital systems, and the interdependencies among all these sectors, any failures could bring cascading system failures.

In a catastrophe like nuclear war, communications would be critical for information sharing, **coordination of responses (locally, regionally, nationally, internationally) and for sustaining transactions**. Access to information is critical to supporting relief and recovery efforts, and how people act in a crisis is influenced by what information they have. Maintenance of an internet is critical for many usual government functions.

NZ could undertake the actions listed above to reduce the risk of digital collapse and its impact on economy and society. These points are covered in more detail in the pages that follow and in NZCat's technical papers (see Appendix).

The impact of nuclear war on ICT/digital/communications

NZ's digital connectivity to the rest of the world remains dependent on very few pathways and a Northern Hemisphere nuclear war, or other significant global catastrophe could have severe impacts on digital and ICT functions in NZ. High altitude detonations of nuclear weapons could cause electromagnetic pulse (EMP) that damages or destroys a wide range of electronic systems, including radio, radar, satellite, and GPS function.[107]

Even without EMP, or any direct targeting of NZ with nuclear weapons, there is a risk of physical destruction of infrastructure elsewhere that NZ relies upon, such as data centres and cloud providers, fibre-optic cables, and satellites around the world, upon which NZ's ICT/digital functioning depends. A handful of fibreoptic submarine cables connect NZ to the rest of the world and virtually all communications and data supporting the function of NZ industry and society is carried by them. Most cloud facilities are located overseas, and even for those that are local, the operational control may be based elsewhere. A lot of this control is US-based, and therefore potentially more at risk of nuclear attacks.

Cyberattacks, whether opportunistic or associated with the war, could intentionally or inadvertently damage or influence critical ICT systems. Critical networks could become overloaded, and human displacement could aggravate this issue. Economic impacts due to failures of digital systems and potential inability to conduct digital payments could be catastrophic. Any systems damaged by these processes, or failing subsequently, may not be able to be repaired due to dependence on imported parts or expertise.

Government operations could be severely curtailed by disruption to ICT/digital systems, and communications necessary to coordinate a response could be severely degraded, given that a lot of services depend on overseas infrastructure. There may be degraded ability to disseminate information and low potential for a centralised response. Decentralised administration might ensue by necessity.

NZ needs a plan to ensure local NZ data/internet can function without dependence on international infrastructure. This might require sufficient domestic data centres and local internet exchange points (IXPs) that allow internet service providers (ISPs) to exchange traffic within the country without relying on international connections. There may need to be solutions, so that sufficient satellite data transmission is available if undersea connections fail, for fibre redundancy in case satellite backup is eliminated, and for a third data or communication channel that does not depend on external infrastructure. For example, uncrewed aircraft or balloons can sustain a communications network.

NZ ICT/digital vulnerability & resilience

Interviews & Survey

Major concerns for interviewees were how to ensure communications with the public in a catastrophe, and how to ensure critical systems like payment processing continues. NZ is dependent on major global supplies of ICT/digital including cloud services (with a heavy NZ government preference for Amazon (AWS) and Microsoft services, yet external factors could impact these providers). Starlink is not a sustainable solution to NZ's limited fibre connections to the world because (1) it is not locally controlled, and (2) it could be lost in a Northern Hemisphere catastrophe. There is lack of redundancy and lack of local expertise. If cloud computing fails then food, transport, payments, and other industries are impacted. Interviewees expressed concerns about maintenance of ICT systems, where failed components could take up to a year to replace, even if in normal times. Cyberattacks were identified as a threat. Quick collaboration across all sectors would be needed in a catastrophe.

Two expert interviewees felt that NZ needs a coordinated National Digital Communications Continuity Plan. The experts suggested that cloud computing should have legal recognition as critical national infrastructure and NZ should invest in its own, including increasing capacity, data location awareness, and security, and using standards like 'infrastructure level 4', NIST, and the RBNZ BSII, as well as conducting 'business resilience mapping' on a national scale. NZ could locate one critical data centre in the North Island and one in the South. These issues could be delegated to MBIE or the Minister for Digital Communications, or a new entity tasked with digital sovereignty rather than 'corporate colonisation'. Whoever is tasked with this needs to understand and have expert knowledge of GCRs.

It is not enough to provide infrastructure; it needs to be regularly audited and tested under likely catastrophe conditions. Standardised processes should be used, and testing should include eg, disconnection from global internet and providers, systematic and continuous evaluation, and expert consultation. Scenarios, red-teaming, and simulations can be used to understand critical service dependencies and the cascading effects of failed systems. The country needs fall-back layers such as satellite internet and to hold providers accountable for infrastructure resilience (potentially through newly proposed regulatory levers).

Local communications and self-reliance would be useful assets, especially for coordinating distribution if food or fuel rationing is required. Resilient layers of public Wi-Fi or auto-switching routers could ensure communication. Local fibre and microwave digital solutions with local and independent units of organisation could help. NZ also needs stocks of spare parts, such as fibre, as well as expertise. There needs to be a low-tech government communications system. This might include UHF radio, or helium balloons supporting communications.

Expert interview participants thought that NZ could achieve a degree of technological resilience through a government-led open-source tech stack which it shares with other like-minded countries (Box 10). Facilitating this could be a National Technology Investment Agency, changing procurement rules, and introducing a National Chief Technology Advisor and Digital Infrastructure Resilience Strategy. The country needs to consider continuity of citizen records and could also invest in a 'local GPT-4'.

Box 10: Resilience Nugget

'We should start to build our own versions of Google and Microsoft 365 and Amazon Web Services, etc - our future is long. Much longer than any of these Big Tech companies will be around. We need to think more long-term, and we need to think and invest in resilience - sometimes at the cost of convenience.'

(NZCat Webinar participant)

The following is a summary of broad resilience measures that expert survey respondents suggested:

- **Implement a coordinated national 'Digital Communications Continuity Plan':** To provide onshore fallback for core communications, payments, government, and internet services.
- **Evaluate national digital communications infrastructure to identify and address key vulnerabilities and capacity issues:** The sector could work towards creating a national digital communications infrastructure that can survive if NZ was to be isolated, and address key capability and capacity gaps, including scenario planning for significant impacts from any electromagnetic pulse (eg, targeted at Australia).
- **Build capability and awareness of security across our own organisations and across the country, including:**
    - **Data location awareness:** Work with international firms to determine where data is held globally (eg, cloud services that businesses rely on). To help businesses understand where key applications are hosted and prepare for potential disruptions.
    - **Strengthen security capabilities:** Strengthen security capabilities across government and ensure national networks and intranets are safe and secure could help mitigate the impact of cyberattacks.
- **Recognise cloud computing as critical national infrastructure:** Invest in resilience measures that enable NZ's digital systems if isolation was to occur (Box 11).
    - One solution could be to implement an open-source software stack in local data centres to control critical services for national security, communications, and resilience, rather than the complacency of outsourcing them to foreign controlled and operated entities and assuming major issues will not occur.
- **Alternative energy sources:** Invest in resilient energy systems ensuring this critical ICT infrastructure can be run without imported parts, off renewable energy, or battery.
- **Community-led resilience:** Create regional community-led resilience leadership structures to understand the ICT/digital risk, learn the options they need to consider, and advise on a roadmap to resilience preparedness.

These measures would require significant planning and coordination within the ICT/digital Communications sector, as well as support from government and other sectors.

Current ICT/digital risk assessment is a start but doesn't address all the issues above

The DPMC has identified a list of Nationally Significant Risks,[108] including critical ICT infrastructure failure, defined as significant loss of nationally significant services due to the disruption or loss of infrastructure, an event which would be overseen by MBIE. Also included are major cyber incidents

for which the GCSB and DPMC are responsible, and disruption to global navigation systems (lead agency 'TBC'). It is not clear whether thinking or planning for these failures includes scenarios of total failure of digital systems and the cascading impacts of global disruption as the underlying National Risk Register remains confidential.

Box 11: Resilience Nugget

Resilience options for cloud data systems

One cloud data expert told NZCat that, 'geographical redundancy has real impacts on performance and that some engineering issues are intractable.' Ideally, you would be able to 'lift and shift' data around and one cloud provider could just drop data into another as required. Ideal, too, would be a 'self-healing' system, with distributed data storage that can move data around when there are threats or outages to minimise impact. Additionally, major overseas data centres often implement solar energy for value and security, but in a nuclear winter scenario this could be the worst option as the level of sunlight is reduced, especially in the Northern Hemisphere.

A NZ Digital Strategy and Action Plan released in 2022[109] identified a range of cybersecurity risks, the international nature of many digital infrastructures, and that interference with digital systems could disrupt organisations and our daily lives. The strategy states that NZ needs secure systems and suitable internet infrastructure, future-focused, resilient communications infrastructures, including hyperscale cloud capabilities and data storage, and resilient, effective communications infrastructure, that is resistant to interference and significant outages. However, the associated Action Plan contains almost nothing on increasing robustness and resilience to global disruption or global catastrophe. One of the NZCat interview study interviewees noted that the Digital Strategy and Action Plan contains a 'technology sized hole'.

Box 12

Disconnect between resilience as assessed vs in practice

The NZ Infrastructure Commission's State of Play report is upbeat about the resilience of NZ's communications sector, arguing that strong market incentives lead to good resilience. However, on 16 February 2023, the impact of Cyclone Gabrielle left over 400 mobile phone network towers offline around Gisborne and Tairawhiti and people were unable to contact families or book transport for days. Flooding was one big causative problem, and Starlink satellite connections helped with the solution, although satellites could be out of action following a nuclear war. These systems were supposedly failsafe, but then all failed at once. The NZ communications sector remains vulnerable and following a global catastrophe, systems may iteratively degrade without the ability to repair them unless spare parts and expertise are available locally.

The NZ Infrastructure Commission Telecommunications 'State of Play' report[110] states that specialised human capital is needed to sustain this system. Also, that telecommunications infrastructure connects families, whānau, communities, and markets, and is essential in enabling a modern economy. It is increasingly important for essential services like healthcare, the movement and storage of data that support businesses and other sectors like transport and energy. Data is an increasingly essential ingredient in societal functioning. The sector and its infrastructure are significant across the four dimensions of wellbeing: Economic, Social, Cultural, and Environmental.

The report identifies the impact of disasters and outages, noting that mobile exchanges are the most critical from a network failure perspective, the main network operators are heavily protected with

redundant links and automatic failovers, but there is major dependence on the electricity network, with critical infrastructure having backup in the form of batteries. However, widespread outages after a period would impact telecommunications services. Rural connectivity is highlighted as an important issue, and we note that it might be particularly essential if trying to coordinate national agricultural resources/production/distribution in a global catastrophe. Without Government participation, it remains unlikely that remote areas will attract private infrastructure investment.

The State of Play report says little about resilience to global catastrophe or major failures offshore but notes that there is little publicly available information on the condition of telecommunications assets.

The NZ Lifelines Council (NZLC) has published updated vulnerability and exposure assessments for NZ's critical national infrastructure in 2020 and 2023.[111] These documents describe the vulnerability assessment process and focus on Energy, Transport, Communications, and Water. Telecommunications is designated a lifelines utility in the CDEM Act 2002, and as of 2023 the sector is developing a Telecommunications Emergency Response Plan along with infrastructure investment.

Telecommunications have a high dependence on reliable electricity, especially at the consumer end. Although key exchanges have batteries/generators, in a major extended electricity outage fuel/supply of fuel would be critical. The NZLC notes telecommunications are 'highly interconnected [in] nature… complicated to predict the impact of specific asset outages.' It certainly appears that a better understanding of the cascading impact of outages is needed.

Additional non-digital systems are provided by Kordia (broadcast infrastructure, including radio, which is robust) and Vital (radio infrastructure and land mobile radio networks not dependent on fibre and/or reticulated power supply). Communications services have many nationally significant customers (mostly emergency services). However, we note that in an extended catastrophe, many sectors such as primary production would require communications to coordinate a national response.

Risk Governance & Risk Management

Cheat Sheet

Nuclear War: NZ Risk Management

Desired outcomes: Effective anticipatory governance of global risk is established, that overcomes silo-based approaches to risk management and resource allocation, reducing harm from GCRs across time.

Main risks of nuclear war: Omission of nuclear war (and other GCRs) from the risk assessment process is the biggest risk to resilience against these scenarios. Some of the largest risks to the wellbeing of Aotearoa NZ originate offshore but spread to affect the entire world.

Risk management options: Accelerate an all-hazards approach to global catastrophic risk and include GCRs in a systematic and comprehensive National Risk Assessment and publicly facing National Risk Register. Establish high-level apolitical, anticipatory, oversight of this process to inform a bipartisan approach supported by legislation.

Institutional reforms:

- **Establish a high-level GCR governance entity that is anticipatory, central/aggregating, coordinating, apolitical, transparent, adaptive, and accountable**
- This could be a Parliamentary Commissioner for Extreme Risk, or Government Chief Risk Officer, advising a bipartisan Parliamentary Committee [See Figure below]
- This should complement & coordinate existing structures such DPMC's national risk team, and NEMA, and oversee systematic risk assessment, dissemination of risk information, and development of critical resilience strategies relevant to GCRs not currently undertaken.
- **Legislate requirements for regular systematic assessment of GCRs and dissemination of risk information via a detailed and publicly facing National Risk Register.**
- Revise the Emergency Management Bill with a GCR lens in mind.
- Expand DPMC's Critical Infrastructure Consultation to achieve not just 'resilient' existing infrastructures, but to identify and invest in needed 'resilience' infrastructures (ie, a Plan B).

Develop a set of National Resilience Strategies/Plans to prepare resilience in case of nuclear war/winter or other GCRs:

- **National Food Security Strategy**
- **National Energy Security Strategy**
- **National Transport Security Strategy**
- **National ICT/Digital Security Strategy**

Co-benefits of GCR risk mitigation:

The resilience approaches listed above would likely

- Increase resilience to GCRs additional to nuclear war
- Increase resilience to a wide range of more common disasters
- Increase awareness of risk and individual/business responsibility for resilience
- Develop a shared mental model of risks, resilience options, and public knowledge that catastrophe can be managed

Central Government Actions:

- **Conduct a systematic all hazards national risk assessment (NRA) engaging experts and stakeholders widely on foundational assumptions (such as scenario choice, discount rate, time-horizon, and decision rules) as well as risk information.**
- Connect the NRA to a capabilities analysis that assesses not just the expected consequences, but also resilience options, marginal benefit of various actions, and the value of acting.
- Put resilience options and trade-offs to stakeholders for a national discussion so the NRA is more than just a list of 'bad things,' establishing an agreed strategy to reduce risk across time.
- Collaborate on the NRA with other high-income OECD island nations, especially for cross-border risks (eg, Australia, Japan, Iceland, Ireland, and the UK).

Provide risk information

- Publicise, and engage with the public on the content of the National Risk Assessment & Risk Register, crowdsource resilience options.

Assess cost-effectiveness of resilience options across risks

- Based on likelihood and impact of consequences, effectiveness of interventions, and additional co-benefits, & prioritise resource allocation

Local Government Actions:

Central Government support for local government to develop and enact plans/measures appropriate given risk information in the National Risk Register

Government investments/infrastructure:

- Invest in a platform for expert and public engagement on the National Risk Assessment
- Invest in a NZ Think Tank to analyse and continually update knowledge and best practice around managing global catastrophes
- Invest in research that continually improves the mechanism and effectiveness of iterations of the National Risk Assessment
- Invest in education and training across the public sector in risk assessment, cost-effectiveness analysis, and anticipatory governance

Governance of Global Catastrophic Risks and an All-Hazards Approach

To develop our nuclear war/winter Hazard Profile, we followed the Swiss approach for assessing national risks, applying it to this hazard from a NZ perspective. We assessed the level of risk from nuclear war in terms of consequences and plausibility. We then connected our risk assessment to a capabilities analysis involving research and consultation with stakeholders and experts. We've presented the risk assessment and 'resilience options' across four core sectors (above). They are 'options' because prioritising them will require a formal cost-effectiveness analysis of their inclusive costs and benefits, to determine which offset the most expected harm from a societal perspective, with this information put to stakeholders for deliberation. However, this process cannot be completed by examining just the hazard of nuclear war in isolation.

We chose the hazard of nuclear war as our example because it represents hazards that currently remain unaddressed in NZ's risk management system. The current division of labour between the National Security Group and NEMA leaves gaps. Lying in the gaps are risks that tend to originate elsewhere, are not malicious threats directed against NZ, but spread to catastrophically impact the entire world. Potentially, most of the risk to NZ is contained in such rare but devastating scenarios.

Hazard Profiles for all global catastrophic risks should be developed, so that these risks can be assessed and managed as a set – this is the all-hazards approach to GCRs (Box 13). An all-hazards approach is important because although each threat has distinctive characteristics, they are not unrelated or mutually exclusive.[112] Many potential consequences are similar across this set of catastrophes. The resilience 'options' we need to prioritise will depend on the *aggregate* of likely exposure and vulnerability to consequences across all GCRs, when all of them are considered.

Considering all-hazards does not require policies applicable to every possible hazard, rather it means we consider all the hazards and then act strategically to reduce the body of risk. This allows coordination and prioritisation across government. The approach should include risk understanding, prevention, preparedness, response, risk communications, collaboration, and governance. A systematic and truly all-hazards approach to risk would ensure that potential global catastrophes, rare but devastating events, and emerging non-traditional risks, are assessed, and resilience options developed. The risk remit needs to be broadened but also needs to be governed.

A Parliamentary Commissioner for Extreme Risks or a Chief Risk Officer could ensure overarching and integrated governance of this critical set of risks (Box 14). This office could be tasked with developing a systematic, publicly facing, National Risk Assessment and National Risk Register, identifying resilience options across all sectors, prioritising, and consulting on these, and recommending resource allocations according to value for money. A well-resourced Commissioner or Chief Risk Officer could advise Parliament and the public, quantifying risk and resilience trade-offs. Resulting priorities would be a set of national strategies as insurance against global catastrophe, and a set of response plans to ensure basic needs are met.

The advantage of having independent apolitical risk assessment is that long-term resilience work could be initiated in bipartisan fashion disconnected from political cycles. Ensuring a statutory risk office would overcome the lack of statutory foundation for risk management work by ODESC, the Hazard Risk Board, or DPMC. It would also place clear responsibility and accountability for coordinating and collaborating with risk systems in other countries.

Box 13: Resilience Nugget

All-hazards Approach to Global Catastrophic Risk[113]

By Rumtin Sepasspour (Global Shield)

What is all-hazards policy?
An all-hazards approach addresses GCR as a whole. It aims to capitalise on the similarities, linkages and relationships between different threats and hazards.

Why do all-hazards policy?
It provides a strategic approach to reducing GCR. It helps reduce the risk from multiple threats at the same time. And it helps tackle threats that are unknown or underestimated. Ultimately, it can prove a more effective, efficient, and holistic policy for GCR.

How is all-hazards policy done?
There are two different ways. The first is '**overarching**' which manages GCR as a set. Overarching policies aim to govern, understand, prevent, prepare for, respond to, communicate about, and collaborate on GCR. The second is '**cross-cutting**', which looks at policy areas or issues that intersect with multiple threats and hazards. Key policy areas include: International relations & foreign policy; politics & governance; security & defence; economics and finance; natural resources & the environment; infrastructure & the built environment; health and healthcare; knowledge & information; tech & innovation; and society & culture.

What do we need to do now?
There's a lot more work ahead.

- GCR experts should study all-hazard GCR and its policy implications.
- GCR research organisations and funders should support more all-hazards GCR research and policy.
- GCR policy advocates should demand more all-hazards policy from the expert community and develop all-hazards GCR policy options for policymakers.
- Policymakers should develop all-hazards GCR policy and engage with the GCR expert community to formulate these policies.

Box 14: Resilience Nugget

A Parliamentary Commissioner or Chief Risk Officer for Extreme Risks

Vulnerabilities enhance risks, and vulnerabilities include inadequate risk governance.

Effective leadership and overarching oversight are needed to ensure sufficient allocation and appropriate prioritisation of resources for management of global catastrophic risks, within a context of other risk management processes. Without a process of centralisation and aggregation, risk analysis may not identify instruments and policies that can address multiple risks and drivers in tandem.

Published, peer reviewed NZCat research notes the benefits of central anticipatory governance of global catastrophic risks.[114] Any entity tasked with such governance needs to be:

- Anticipatory; Central/aggregating; Coordinating; Apolitical; Transparent; Adaptive; Accountable

A Parliamentary Commissioner for Extreme Risks or a Chief Risk Officer could be tasked with developing a National Risk Register. Such a register should be public in substantial form in democratic countries. There are arguments that some highly sensitive content should be redacted to avoid broadcasting security weaknesses, encouraging perverse investments, or adversely affecting international relations. However, the presumption must be towards open government.

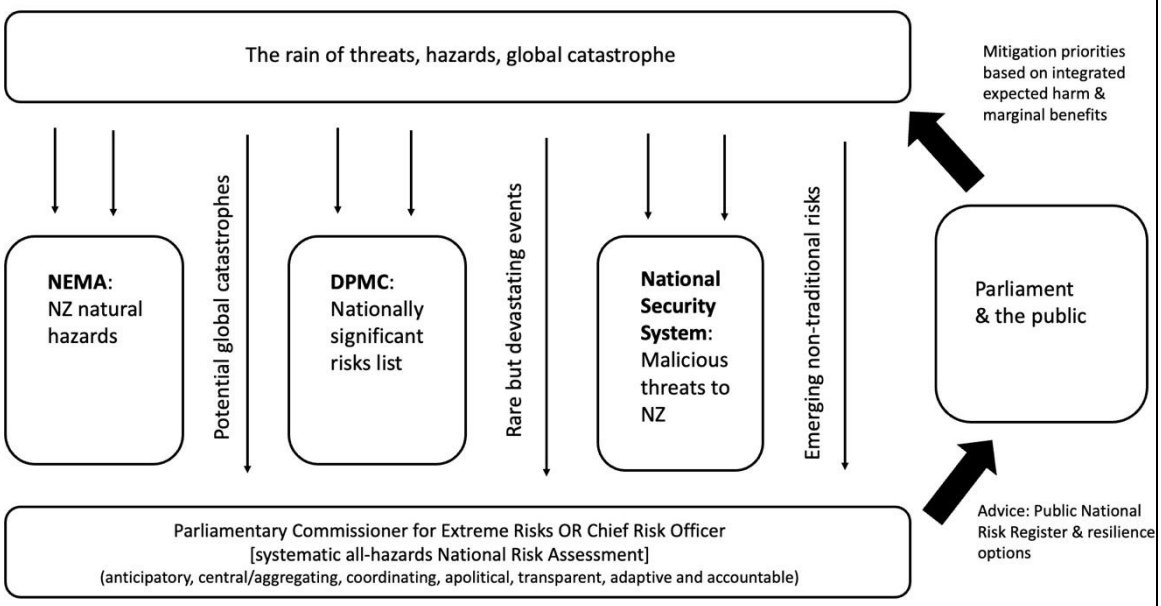
The public needs independent assurance that the government acknowledges risk and has plans for addressing (or justification for accepting) risk. Transparency is an important commitment device: if a risk is broadcast, it must be addressed (or accepted). The decision to accept risk hinges on risk appetite, and the relevant appetite is the risk appetite of the public and other stakeholders, including a process for representing future generations.

Identifying the Gaps in Current Approaches to GCRs

In one vision for governance of GCRs, a Parliamentary Commissioner for Extreme Risks or a Chief Risk Officer would learn from current risk management entities, consider global evidence on GCRs, identify gaps, and produce the systematic National Risk Assessment, including GCRs.

We can conceive of the gaps in the present approach to management of nationally significant risks by imagining that the suite of risks ‘rain down’ on NZ (Figure 10). NEMA’s remit largely catches natural hazards originating in NZ (flooding, volcanoes, earthquakes, etc), and focuses predominantly on response. The National Security System focuses mainly on malicious threats to NZ (terrorism, cyber threats, etc), DPMC’s list of ‘nationally significant risks’ catches some global risks such as a fuel shortfall (10% shortage is modelled in MBIE-commissioned scenarios) but overlooks many GCRs.

Figure 10: Which organisations do, or could, catch the rain of risks?

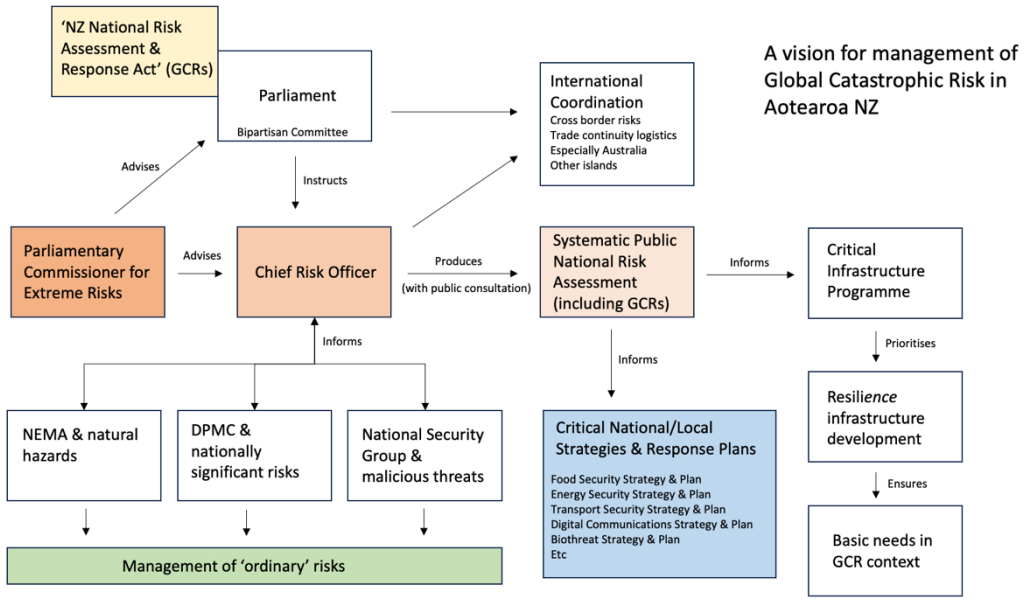


A fully comprehensive national risk approach would see NEMA, management of nationally significant risks already identified by DPMC, and the National Security Group, as effective subcomponents but would also ensure that large scale global risk was addressed, in addition, in coordinated fashion, across the silos of government and industry.

This vision of governance could ensure that production of a publicly facing National Risk Assessment informs a set of Critical National & Local Resilience Strategies and Response Plans for key sectors explicitly addressing important common consequences across GCRs. For example, a National Food Security Strategy, National Energy Security Strategy, National Transport Security Strategy, and Digital Communications Security Strategy, with GCRs as the explicit target. The 'cheat sheets' for the four core sectors above provide a starting point for conceiving of these Security and Resilience Strategies (orange boxes) and Response Plans (blue boxes) and could be further developed, with other sectors added.

The Assessment would also inform the Critical Infrastructure Programme, extending the scope and scale of scenarios considered, thereby ensuring a plan for basic needs to be supplied in the context of a protracted global catastrophe. Finally, the governing entity would independently advise Parliament (ideally a bipartisan committee supported by legislation mandating the relevant risk assessments and strategies) and coordinate with international peers on cross-border risks. This arrangement is depicted in the below (Figure 11), and we explain the key components in what follows.

Figure 11: A Vision for Governance of Global Catastrophic Risks in NZ



A Systematic Public National Risk Assessment & Risk Register

NZ needs a systematic and comprehensive National Risk Assessment and publicly facing National Risk Register (Box 15 & Box 16). This would allow scrutiny to ensure there are not major gaps in NZ's risk readiness, and to ensure that hazards such nuclear war/winter and other global catastrophic risks are addressed. Others have made the same call, for example, former NZ Chief Science Advisor Sir Peter Gluckman.[115] Key gaps include the omission of many risks that originate overseas, are not malicious threats to NZ, but spread to catastrophically impact the world (such as nuclear war/winter).

Gluckman and Anne Bardsley noted in early 2023 that there will be ongoing acute events, increasing climate impacts, and harms from a degrading digital and information environment. Programmes such as the UN's Sustainable Development Goals (SDGs), the Paris Climate Accords, and the Sendai Framework for Disaster Risk Reduction, are all intended to work in concert to reduce risk and optimise development by 2030. However, progress remains variable, and the systemic disruption of the Covid-19 pandemic has impacted progress. There are current shortcomings of the risk assessment process:

- Insufficient transdisciplinary science and knowledge brokerage between science and policy.
- A low priority given to developing redundancy and resilience (reactive vs proactive policy).
- The problem of short-termism in decision making.
- There is insufficient 'risk listening', ie, decision makers are not open to taking on board the risk assessments

Gluckman and Bardsley propose that NZ undertake an 'extended' and 'independent' National Risk Assessment. The resulting product must be 'public facing as well as policy facing'.

Box 15: Resilience Nugget

Revolutionising National Risk Assessment (NRA): Improved methods and stakeholder engagement to tackle GCRs and existential risks

We published a peer-reviewed academic paper identifying two shortcomings of National Risk Assessment (NRA) processes: (1) lack of transparency around foundational assumptions, and (2) exclusion of the largest scale risks (namely GCRs and existential risks).[116]

We demonstrated how changing fundamental analysis assumptions changes the ordinal prioritisation of the risks. This is important because the basis for assumptions is often not published, is opaque to end users, or has not been authorised by public debate and stakeholder input (noting that future generations are also stakeholders and need a process to represent them).

- Even when only considering people alive today, and with a time horizon of just one year, the consequence in expectation of several existential risks is higher than all other risks commonly included in NRAs.
- The exclusion of global catastrophic risks (GCRs) and existential risks to humanity from NRAs is a critical process error.

Our analysis of five NRAs (and Kohler's 2023 analysis of nine[117]) shows that no NRA appears to include many, if any, GCRs or x-risks. Surprisingly the Norwegian NRA mentions in one sentence that a large volcanic eruption could 'cool the earth by several degrees'. But then never mentions the global consequences of what could be the single most catastrophic impact contemplated by any NRA.

It is essential that governments agree key assumptions with citizens before conducting NRA. Assumptions include methodological and normative choices that determine which risks are included, how they are characterised over time, and how uncertainties are expressed in risk communication.

Scrutiny must first be applied to these underlying process assumptions, then to the resulting empirical claims, and finally deliberative prioritisation (for prevention, mitigation or further research) can occur.

We proposed the development of a freely available, open-access, risk communication and engagement tool to facilitate discussions on NRA. Aspects of such a tool could be tailored to experts and other aspects to the general public. The tool could be used in conjunction with citizen assemblies and other effective engagement methods.

However, national risk assessment processes of the past have exhibited significant weaknesses.[118] These will need to be explicitly overcome to ensure that the assessment can act as a repository for risk information and a foundation for action.

- **National risk assessments, even those with the best intentions, omit critical risks.** Decision makers who exclude risks from the assessment are exposing countries to increased risk and are circumventing a democratic discussion of risk prioritisation.
- **National risk assessments often omit the entire class of global catastrophic risks** (GCRs). Assessments thereby plausibly omit analysis of most of the actual risk.

- **National risk assessments seldom engage the appropriate spectrum of stakeholders**. For example, the NZ National Risk Register was developed but then kept confidential. The UN has noted that lack of access to risk information is a critical weakness of present disaster risk reduction activities. There is risk of downplaying political, normative, or ethical questions.
- **National risk assessments have produced highly variable assessments of cross-border risks**. This implies that working with other countries to share analyses and align expert findings would be valuable.
- **National risk assessment can become politicised or focused on recent salient events to the exclusion of major likely harms**. Resources often end up allocated to studying comparatively lesser risks in forensic detail, rather than addressing the low-hanging fruit for big inevitable ones.
- **National risk assessments, and consequence-probability risk matrices, fail to appropriately represent the salience of risks**. For example, categories are often used to represent the likelihood and consequences of hazards in a risk matrix and the salience of very severe risks such as global pandemics is not readily apparent.
- **National risk assessments can become outdated and scheduled updating is needed**. Notably the US has recently passed the US Global Catastrophic Risk Management Act (2022), requiring such assessments (Box 17).[119]

Resourcing and Cost-effectiveness

Finally, resourcing of national risk management needs to be allocated in proportion to the risk (while also considering the marginal benefit of additional resources, or reallocation of existing resources, and the likely value obtained). It will be important to look not just at hazards in isolation, but the totality of risk, common consequences across hazards, and interactions of hazards, to inform targeting of resources. It is entirely possible that many individually unlikely events pose a probable common risk when surveyed together. Cost-effectiveness analyses of interventions should consider this.

Public engagement should inform resource prioritisation decisions

Initiatives such as public surveys, community hui, or citizen assemblies, could facilitate important values discussions that inform prioritisation decisions.[120] NZCat was told repeatedly, by many stakeholders and experts engaged, that appropriate risk management of nuclear war and global catastrophes requires extensive community and public engagement. The question of values, or 'what are we saving?' must be discussed, identifying the needs of NZ, the needs of trade partners, the needs of humanity, the rights of future generations, as well as the level of acceptable risk. Experts told NZCat that these discussions might be more fruitful if facilitated to reach agreement on 'decisions' rather than 'assumptions', recognising that not everyone holds all the same beliefs, but that shared will for courses of action can be found. The 'resilience options' approach could support this.

Engagement should recognise the day-to-day reality of people's lives and risk language should avoid hectoring or protectionism. The NZCat Webinar panel discussion (October 2023) identified that risk management processes should recognise that the day-to-day reality for many people is a struggle to put food on the table. Communities may not always be receptive to bigger picture resilience discussions, even when catastrophes have recently struck. People may find it hard to

engage with high-consequence unfamiliar scenarios and communities don't have the resources to prepare for every eventuality.

Therefore, it would be useful to focus on building capabilities to respond to a range of hazards, with focus on preparedness measures that have co-benefits day-to-day. One panellist called this 'resilience by stealth.' Additionally, risk management language is traditionally 'protectionist', using terms like 'threat', 'control', 'eliminate', but complex threats can't necessarily be controlled. The upshot is that we need to live with some risks and risk management language may need to change to be more symbiotic ('adapt', 'accommodate', 'live with', 'adjust', 'pivot'), with our culture and practices being more accepting and embracing of change and preparing for change.

Box 16: Resilience Nugget

The UK National Risk Register

- In 2023 the UK published an updated, improved, and publicly facing National Risk Register (NRR) covering 89 major threats,[121] including key global risks such as the failure of all transatlantic communications cables, or disruption of global oil trade.
- The UK NRR includes potential GCRs such as massive (VEI7+) volcanic eruption, human pandemics and emerging infectious disease, and nuclear 'miscalculation'.
- **Massive volcanic eruption** could lead to a 'humanitarian crisis', 'major disruptions to supply chain' and 'hazardous weather.'
- **Emerging infectious disease** with a '25% case fatality' might require 'border measures', and very widespread contact tracing and isolation potentially of hundreds of thousands of people.
- **Nuclear miscalculation** was categorised as between 5–25% likelihood in next 5 years (ie, 1–5% per year). The UK National Risk Register states the impact of this would likely be 'significant' and notes a 'catastrophic' impact is possible, with the climate effects of nuclear soot leading to global famine (no doubt with supply chain impacts at least as significant as for volcano above).
- **The UK NRR was informed by a House of Lords Inquiry into 'Risk Assessment and Risk Planning: Preparing for Extreme Risks**,'[122] and the UK Government Resilience Framework.[123]
- The UK NRR is still far from comprehensive, but it is a strong step in the right direction, providing risk information to those who wish to build resilience.
- NZ could undertake similar assessments and develop its own framework.
- NZ could also learn from the UK's 2023 Biological Security Strategy,[124] which demonstrates a robust approach to one selected GCR.
- NZ could leverage its own plans for 'system reform' articulated in the 2023 NZ National Security Strategy to ensure overarching, high-level, coordinated governance of GCRs.
- **Multilateral international cooperation should now occur to align risk assessments and options** for managing cross-border risks.
- If the Covid-19 pandemic taught the world anything it is that every country going it alone leads to a chaotic response that benefits no one.

Box 17: Resilience Nugget

The US Global Catastrophic Risk Management Act 2022

- Recognising the potentially unbearable impact of global catastrophic risks, the US passed the Global Catastrophic Risk Management Act in 2022.[125]
- The Act requires the Secretary of Homeland Security and the Administrator of the Federal Emergency Management Agency to coordinate an assessment of GCRs within one year, and every ten years thereafter.
- The report must be coordinated with senior officials from 16 other specified national agencies.
- Each Federal Interagency Operational Plan will then be updated to include an annex containing a strategy **to ensure basic needs are met in the aftermath of global catastrophe**.
- NZ could replicate this Act, with the National Security Group and NEMA coordinating the report, perhaps in conjunction with a Chief National Risk Officer or Parliamentary Commissioner for Extreme Risk.
- The upcoming (2023) shake-up of NZ's research sector is an opportunity to include a National Science Mission on Mitigating GCRs that could inform ongoing GCR assessments and response planning.

Critical Infrastructure Programme and Provision of Basic Needs

NZ Lifelines Council

The NZ Lifelines Council produced it's 2023 National Vulnerability Assessment of NZ's critical national infrastructure with a focus on Energy, Telecommunications/Broadcasting, Transport, Water, Wastewater and Stormwater, Flood Protection, Finance (Payment Services), Solid Waste, and Data Storage/ICT. The focus is largely on the robustness of presently existing infrastructure, and on local (to NZ) natural hazards (though includes other hazards such as cyberattacks, pandemics, space weather and GPS disruption). The Assessment considers infrastructure that is 'critical', which critical customers the infrastructure serves, and the interdependencies among infrastructures (Figure 12).

The Assessment could be improved as it does not appear to contemplate long-term global disruption (months, years), loss of NZ's connectivity with the world (either by severance of digital connections or cessation of trade), or climate impacts of catastrophes such as nuclear/volcanic winters.

Hospitals and other emergency services are seen as examples of primary critical customers, although the assessment also considers, for example, 'major industry' and 'fast moving consumer goods', including freezing works, dairy processing, primary food sectors, including their interdependence, eg, on electricity and water supply. It is not clear, though should be, whether on-farm primary production activities count as 'critical customers' (eg, when should tractors be prioritised for fuel supply?)

A complementary assessment of critical infrastructure using a 'GCR lens' would enhance the approach of the Lifelines Council, and may identify different risk consequences, including those impacting the whole country (where out-of-region help is unavailable), and where different critical customers, eg, grain farmers, or biofuel producers, could be critical in certain global circumstances.

Figure 12: Interdependencies among NZ sectors (post-disaster) as reported by the NZ Lifelines Council

The degree to which the utilities listed to the right are dependent on the utilities listed below	Fuel	Roads	Telecomms	Electricity	VHF Radio	Broadcasting	Air Transport	Solid Waste	Financial&Cash Payments	Water Supply	Stormwater/Flood Protection	Wastewater	Sea Transport	Gas	Rail	Total Dependency
Fuel		3	3	3	3	3	3	3	3	3	3	3	3	3	3	42
Roads	3		3	3	2	2	3	3	3	3	3	3	3	3	3	40
Telecomms	2	3		3	3	2	2	2	3	3	3	3	2	3	2	36
Electricity	2	2	3		3	3	3	2	2	3	2	3	3	2	2	35
VHF Radio	2	2	2	2		2	3	1	2	2	2	2	3	2	2	29
Broadcasting	2	2	2	2	2		2	1	2	2	2	2	2	2	2	27
Air Transport	2	2	2	2	2	2		1	2	2	2	2	1	2	1	25
Solid Waste	1	3	2	2	1	1	1		1	2	2	2	1	2	2	23
Financial&Cash Payments	3	1	1	1	1	1	3	3		1	1	1	1	1	1	20
Water Supply	1	1	2	1	1	1	2	1	1		1	3	1	1	1	18
Stormwater / Flood Prot.	1	2	1	1	1	1	2	1	1	1		1	1	1	1	16
Wastewater	1	1	1	1	1	1	2	1	1	1	1		1	1	1	15
Sea Transport	1	1	1	2	1	1	1	1	1	1	1	1		1	1	15
Gas	1	1	1	1	1	1	1	1	1	1	1	1	1		1	14
Rail	1	1	1	1	1	1	1	1	1	1	1	1	1	1		14

Figure 3-6: Interdependency Matrix – During / Post Disaster Event

CATPLAN

NEMA has recently been undertaking a new programme of catastrophe planning (CATPLAN), which involves pushing scenarios not just to the point of system failures (to learn lessons for how to prevent failure) but also beyond system failure, with the intent to discover what emergent arrangements might result. More multi-sector and interagency workshopping of these kinds of scenarios could be encouraged and could be useful for considering GCRs.

Interview & Survey Findings

Expert interview and survey participants with experience in risk management, foresight, and planning, supported the 'all-hazards' approach to risk management, noting that this requires both long-term planning and scenario analysis that includes comprehensive and imaginative scenarios, including large scale global threats, with a focus on critical systems like food, energy, transport, and communications.

Long-term may need to mean a generation, 100 years, or even longer, on a scale to anticipate potential resource depletion, while maintaining the ability to rapidly pivot in the face of technological advances. Achieving this would necessitate broadening NZ's current national risk approach and increasing transparency in relevant processes. Experts again highlighted the immense interdependency among sectors in NZ. Failure of one can mean failure of all.

The experts identified potential weaknesses of the proposed NZ Emergency Management Bill, with its focus on individuals rather than organisation functions, as well as insufficient transparency around

risk assessment and policy (Box 18). They felt that the Bill would be unable to deal with the scale and complexity of the GCR class of risks. They also criticised the absence of a statutory foundation for national security arrangements, which are often reliant on Cabinet decisions. This could be problematic, particularly in managing major hazards.

Box 18: Resilience Nugget

The Emergency Management Bill (2023) could be improved

- The Bill provides for government powers in an emergency but needs to balance this with requirements to undertake appropriate prior risk analysis, preparedness planning, and prevention. Additional minimum standards should be set.
- There should be plans for critical sectors to make each more resilient in advance and specify how emergencies will be managed (see our 'Cheat Sheets' above).
- Include provisions that allow negotiation in advance regarding government compensation for requisitioning, and require this for foreseeable events, thereby incentivising measures to avoid the need for such requisitions.

Interviewees specifically viewed the current Emergency Management Bill as ill-suited for responding to potential Global Catastrophic Risks (GCRs) due to several factors:

- *Dropping the language of 'civil defence'*: Where this has been done overseas there has been reduction in some infrastructure supporting risk management, public planning and discussions of the impact of war, yet war is the most consistent theme shaping human history.
- *Need to ensure a statutory basis for key risk management entities (ODESC, DPMC, etc)*.
- *Scale of catastrophe*: The bill may lack the capacity to address a global catastrophe, such as a Northern Hemisphere nuclear war scenario.
- *Multi-sectoral complexity*: The bill may struggle to tackle the intricate and interconnected challenges spanning various sectors.
- *Need for specialised approaches*: GCR planning, and response demand a more specialised and independent approach, potentially supported by specific legislation (as is the case in the United States).
- *Need for an open and inclusive approach*: centred on sustainability and resilience, which should extend beyond government powers to harness the knowledge capital and resources of the private sector and the public.

Interview participants identified a paradox of preparedness, with some risks identified but not addressed. Leaders have scarce attention and an immediate focus, which is a barrier to resilience. There is a lack of government foresight work. A proactive framework is lacking and there is no National Risk Strategy. It is not always clear who should lead national responses, and a central response may not always work in extreme catastrophes.

The experts felt that local regions in NZ need more self-sufficiency with fuel and food. This could be achieved with regional transport hubs, and proactive strategic planning – rather than solutions that just 'sound good,' as well as supporting the ability of communities to function even in significant disruption (including to communications, see 'ICT/digital' section above), this requires investing in critical infrastructure and careful decisions around levels of 'essential' service.

Risk experts suggested that there should be more (continuous) national focus on sustainability and resilience and legislation should provide for 'foreseeable emergencies', which includes planning for

large risks beyond just scaling up smaller response plans. Sufficient resources need to be allocated for legislative review and a National Risk Assessment and election reform ahead of time could allow for solutions to be possible (overcoming political stasis). There could be more use of the National Security System and private sector.

A Disaster Recovery Authority could oversee post-catastrophe work in conjunction with pre-disaster plans and a long-term recovery strategy. The experts suggested that NZ should consider the creation of an independent think tank or government organisation for catastrophic risk strategy (Box 19). This could help overcome partisan politics and enable longer-term thinking. Additionally, resilience beyond specific hazards is important, with long-term planning, redundancy, and comprehensive scenario analysis needed.

Finally, the risk experts noted that the government may lack the funds for a full rebuild, and some prioritisation processes are needed. There needs to be management of expectations, and nurturing trust, social networks, and vertical connections, given the risk of civil unrest or political polarisation.

Box 19: Resilience Nugget

Establishing a National Global Risk & Resilience Think Tank

Imagine it is 2025 and in response to the increasing risk of global catastrophe in a deteriorating strategic environment, and the complex challenges posed by catastrophic events, the government of NZ has created a dedicated National Resilience Think Tank (NRTT). The NRTT also supports a new National Science Mission on resilience to global catastrophe.

This NRTT is comprised of a permanent staff as well as relationships with industry, local bodies, and community groups. It conducts research and analysis on large scale risk and provides evidence informed information and advice on oversight, coordination, and a strategic approach to large scale, long term national resilience. Its independence ensures the monitoring of government processes for endogenous (within government) risks to long-term outcomes, which can be frankly and publicly discussed.

Additionally, the government has committed to spending 1% of the value of each large public infrastructure project, such as Dunedin Hospital, Transmission Gully, or the proposed Auckland Harbour Tunnel, on systematic risk assessment, comparative cost-benefit analyses, resilience planning, and investment in resili*ence* infrastructure, expertise, and communities.

The NRTT conducts independent and evidence-informed cost-benefit analysis from a long-term and societal perspective to inform and prioritise these decisions and considers future generations.

Objective: The NRTT has a clear mandate to proactively inform national resilience, helping to prepare the country to effectively respond to and recover from global catastrophic events.

Composition: Comprising a multidisciplinary team of experts drawn from diverse fields, including global catastrophe research, disaster management, infrastructure, healthcare, economics, social sciences, and more, the NRTT aims to foster an integrated, holistic approach to national security and resilience.

The NRTT recognises that a huge amount of harm to wellbeing comes from rare but devastating events (for example Covid-19 was responsible for 95% of all disaster deaths in the period 2000–2023) and finding ways to reduce this harm by even 10% would have immense benefits.

PART C: Other Important Issues

Image credit: MidJourney

Summary of Other Important Issues

Resource constraints meant that NZCat's focus in 2023 was on the four core sectors of Agri-food, Energy, Transport, and ICT/digital, plus risk governance and risk management processes (as above). However, the research identified many other key issues, which are discussed below. In brief:

- **Water Supply** could be disrupted by electricity supply failures, especially if there has been an electromagnetic pulse, longer term maintenance may be difficult without trade.
- **Supply Chain/External Trade** may be catastrophically impacted, not just 'disruption' which is planned for, but 'destruction' from which recovery might be difficult. A Plan B is needed, and NZ should collaborate with regional partners ahead of time on logistics after a GCR.
- **Industrial Inputs** will likely be in short supply, NZ should strategically consider what it can produce or recycle domestically, and what (of value in the aftermath) could be traded externally for critical inputs in a GCR context.
- **Local Manufacturing** may have to supply all manufactured goods post-catastrophe. NZ should consider investing in the ability to manufacture basic components necessary for essential utilities and food production.
- **Economy & Finance** could falter if digital transactions become degraded. Circular localised economies and a plan for complete failure of digital payments could be developed.
- **Border Issues** including concerns about overwhelming immigration, military challenges, and the arrival of disease need to be considered, with planning for surveillance and quarantine.
- **Health Security** can be improved by developing NZ's capabilities against benchmarks like the Global Health Security Index, while ensuring clean water and secure food supply.
- **Social Response and Governance** will be major factors, without precedent, following nuclear war. Systems failures may make local governance and community cooperation particularly salient, and NZ should foster these capacities.
- **Legal & Regulatory** frameworks should mandate the assessment of GCR risks and dissemination of public information, ensure development of critical infrastructure needed for resilience, and provide appropriate powers, especially to local governments.
- **Māori** should be deeply engaged to advise and cooperate on all the issues above, strengthening linkages between local government and marae/iwi, and incorporating traditional values around wellbeing, resilience, and concern for future generations.

Water

Resilience Options

To mitigate any impact of Northern Hemisphere nuclear war/winter on water supply, NZ could ensure the following:

- Reduce reliance on irrigation for food production
- Ensure electricity generators (eg, solar, wind) at key treatment/pumping facilities
- Identify water sources that can be accessed/distributed without electricity/connectivity
- Undertake rainfall modelling for nuclear winter
- Audit the inputs needed for water treatment and ensure backup supply
- Keep up-to-date with water infrastructure maintenance
- Maintain water infrastructure expertise in NZ
- Widespread installation of roof collection & storage

Context

Water is essential for drinking, waste management, and irrigation. In a nuclear war/winter context water pumps and supply could be disrupted by electricity disruption (potentially EMP), or disruption to internet or telemetry functions, lack of access to potable water, a damaging event (eg, earthquake) after the nuclear war, freezing pipes or changes to precipitation in a nuclear winter, or breakdowns and inability to source replacement parts (eg, bearings).

The NZ Lifelines Council[126] notes potable water requires both quantity and quality, and both can be affected (eg, droughts, pathogens), that larger and more critical sites tend to have on-site backup generation. However, these could still be vulnerable to interruptions to fuel supply or other events. Other developed nations have suffered major water outages. For example, supply to 180,000 people was cut off in Jackson Mississippi in August 2022 due to 'a set of accumulated problems based on deferred maintenance that has not taken place over decades.' Urban areas should not take water supply for granted.

The NZ Infrastructure Commission 'State of Play' report on water[127] found that electricity supply is crucial, the number of days of stored treated water supply is very low (0.5–2 days), older pipes are brittle, and there are difficulties accessing technical skill to provide water infrastructure.

Reticulated water leakage is a substantial problem in NZ, with Wellington, for example, losing 40% of water to leakage. This is an example of neglected infrastructure throughout the country and can be compared to other earthquake prone places like Tokyo, where leakage is only a few percent. The impacts of Cyclone Gabrielle in 2023 underscored the poor state of water and sewerage system infrastructure in NZ.[128]

With a new government leading NZ into 2024, and the proposed 'Three Waters' programme now under substantial review, it remains to be seen what government water infrastructure planning will look like, however, it will need to address resilience to GCRs. This is a survival issue.

Supply Chain/External Trade

Resilience Options

- Conduct a study of regional self-sufficiency (eg, closed system including NZ, Australia, PNG, Indonesia, Philippines, Pacific Islands)
- Nurture 'resilience alliances' among the preceding partners
- Diversify trade links, eg, explore options such as the 'Southern Link' (Box 20)
- Develop appropriate physical supply chain infrastructure for independent regional trade.

Context

The 'Transport' section above details some options for reconfiguring infrastructure supporting NZ's domestic supply chains to mitigate the impacts of a Northern Hemisphere nuclear war that causes catastrophic disruption to global trade. But there are additional actions NZ might consider for protecting or re-establishing trade beyond its borders, as follows.

NZCat expert workshop participants thought that supply shortfalls are a major concern for economic shock and recovery. If global communications systems are impaired, even ordering supply could be difficult. NZ might be targeted as a 'food basket' by other struggling countries, but this could be an opportunity for trade in essential commodities. Maintaining NZ-Australia trade would be important.

DPMC includes 'major trade disruption' in its list of Nationally Significant Risks, although the publicly facing details are scant and it appears that attention is mostly focused on disruptive processes (rather than destructive ones), and on limited commodities, eg, disruption to trade in animal products due to foot and mouth disease.

Countries such as the US have undertaken major supply chain reviews,[129] focusing on critical imports, aiming to rebuild domestic manufacturing, investment partnerships with value-aligned nations, diversify international suppliers, and improve incentives for longer-term resilience. We note challenges with ex-ante supply agreements that may not hold up in a catastrophe. So, there is need to cultivate a context that fosters collaboration and resilience, increasing the probability of good outcomes.

NZ agencies are undertaking work to catalogue criticalities in trade and supply. For example, the Productivity Commission commissioned a report that identified structural, geopolitical, physical, and globalisation-related changes to supply chains. Possible solutions include reshoring, near-shoring, and friend-shoring supply, with inventory redundancy and stockpile.[130] The Commission conducted a preliminary analysis of 6,678 goods imported from 145 countries and identified 513 concentrated imports.[131] MFAT has led inter-agency work on supply chain resilience, including policy options for 6-months to 1-year disruptions. MBIE are expanding this work in 2023. However, it will likely prove difficult to catalogue (let alone stockpile) every 'essential' item that NZ imports. Given the broad range of possible disruptions and high uncertainty, it may be more fruitful to nurture more diverse, local, and regional trade and supply chains, which could be leveraged during global catastrophes.

A critical part of planning for major trade disruption due to global catastrophe would be to work with regional partners, such as Australia or Indonesia, to determine what essential commodities each could supply and what local regional infrastructure is needed for independent operation of this trade. This is important because small, advanced economies do not have the productive capacity for strategic autonomy in technology or manufacturing. Two areas of further analysis would be fruitful, (1) what can NZ produce or pivot to producing in a GCR that these partners will want, (2) how can regional networks maximise diversity of commodities to satisfy broad demands.

Box 20: Resilience Nugget

The 'Southern Link': Trade route diversification and resilience

- Destruction of critical Northern Hemisphere trade infrastructure could occur in a nuclear war, or other GCR, eg, ports, airports, pipelines, ships, navigation systems.
- NZ could end up isolated from global trade routes, lacking in local infrastructure to support re-establishment of trade at scale, with regional partners such as Australia or Indonesia.
- Diversification of trade routes could help mitigate this impact and provide new opportunities during normal times.
- The Te Aoutanga Aotearoa Southern Link Trade Route has been proposed as a technology driven trade route between North Asia and South America via NZ.[132]
- One proposal would see six iwi owned and managed 'hyper location hubs' in NZ supported by higher education institutions.
- This would put NZ in the middle of a global value chain, but more importantly would encourage development of local infrastructure to support regional connectivity following a global catastrophe.
- Resilience can be built into supply chains in three ways: a shift from 'just-in-time' to 'just-in-case' inventory management, the nearshoring or reshoring of manufacturing closer to the final point of retail, and an increase in transparency and monitoring to boost flexibility.

Industrial Inputs

Resilience Options

- Invest in support for key raw material industries for local supply, but also to have something to trade for essential inputs in a global catastrophe (especially where such investment reduces climate emissions, eg, electric smelting, biofuel production).
- Conduct simulations, walk-throughs, and red-teaming of scenarios on loss of critical supplies.
- Create plans for what to do if even well-established critical suppliers are lost.
- Consider selected strategic stockpiles of the materials with the most impact if lost.
- Develop resource/waste recovery programmes.
- Accelerate electrification in case critical industrial materials become scarce.
- Conduct a bottom-up analysis of 'minimum viable industry' to prioritise industrial inputs.

Context

It is not only acute catastrophes like nuclear war that put at risk the supply of raw materials. The World Economic Forum sees future resource constraint, competition, and control as three of four business-as-usual scenarios in their 2023 Global Risks Report.[133] The International Energy Agency counted nearly 200 national policies and strategies surrounding 'critical minerals.'[134] Increased future demand and competition for strategic resources might mean that it is better for a country like NZ to accelerate resilience building, to protect against acute hazards, but also longer-term trends.

A global catastrophe will have a massive impact on the availability of industrial inputs. NZ needs to anticipate this and have plans to wind down certain industries in an orderly fashion and more appropriately distribute these resources should the circumstances arise. As the 1980s NZNIS put it, 'we would need to restructure society and accept a lower standard of living.'

Australia produces a lot of mineral inputs. Access to these might be secured in an ongoing catastrophe in exchange for a NZ export (eg, biofuels), if NZ anticipates post-catastrophe resource demands and invests in the ability to produce. However, for some processes, NZ and Australia are both dependent on the same inputs.

NZ is taking some action to build resilience in raw material production, for example the government's $140m investment in an electric arc furnace for the Glenbrook steel plant. Other options could be investigated.

A more circular economy can help reduce dependence on raw industrial materials. For example, waste-to-energy programmes, landfill mining, and recycling. Resource surveys could be undertaken, to establish sources for during a catastrophe, even if not economic to extract in normal times. Difficult to extract resources such as coal might be mined and stockpiled, preventing their use unless a global situation presents no other option.

Box 21: Resilience Nugget

Policy Horizons Canada Think Tank: 'Geotechnomics'

'To compete in this ever-changing global landscape, countries must not only be able to innovate and produce at scale, but also access strategic assets such as critical minerals, semiconductors, biochemical ingredients, and big data. This may require cooperation between countries with divergent values. Governments may have to engage in a continuous process of discovery, as what is strategically important today may not be so tomorrow. Also anticipate the possibility, even if low in probability, of losing cooperation of countries that supply essential or strategic goods.'[135]

Manufacturing

Resilience Options

- Develop a National Manufacturing Strategy or Sovereign Manufacturing Capabilities Plan that prioritises manufacturing capacity that supports basic food production (eg, biodiesel production, repair of farm machinery, and food produce transport via electrified rail and trucking).
- Explore manufacturing requirements to sustain the electrical grid and a domestic internet.
- Explore options for sustaining trade with Australia (given its much larger manufacturing base).
- Consider developing advanced and versatile 3D printing capability.
- Analyse datasets such as StatsNZ imports lists and identify critical dependencies, crowdsource workarounds and plan to adapt in case imports cease; learn from case studies of low-tech solutions such as food production in Cuba in the 1990s.
- Develop and retain a highly skilled, expert manufacturing workforce.
- Build more from wood, wool, and local products.
- Foster a manufacturing sector developing 'future foods' such as seaweed, algae, insects, and industrial proteins.

Context

NZ has a relatively limited manufacturing base and consistently imports more manufactured goods than it exports. In a global catastrophe such as Northern Hemisphere nuclear war, it may be impossible to access manufactured goods essential for the maintenance of survival systems like transport, food, agriculture, and water.

MBIE's 2018 report on manufacturing in NZ is divided into seven subsectors: 'food and beverage', 'wood and paper', 'machinery and equipment', 'chemicals and refining', 'plastics and rubber', 'metals' and 'other manufacturing'.[136] A large part of manufacturing in NZ – as is the case in most developed economies – is focused on the production of low and medium-low technology goods eg, food and beverage products, metal products, textiles, plastics, paper, timber and building materials.

A lot of NZ firms conduct their manufacturing offshore, this poses risk in the context of a GCR. However, there is little discussion of risk in MBIE's Advanced Manufacturing Industry Transformation Plan,[137] with 'risk' mentioned only in the context of health & safety risk, risk of capital investments, and risk of investment in R&D. These kinds of plans need to be interpreted in conjunction with a GCR lens with longer-term resilience considered.

MBIE emphasises supply chain resilience and notes Australia's 2020 Modern Manufacturing Strategy, with large investments in high-quality and sustainable manufacturing. We note that many advanced economies are reshoring manufacturing, NZ could consider growth of high-value non-primary manufactured exports, chosen strategically to enhance self-sufficiency should a GCR strike. Attracting a diverse high-skilled workforce to NZ is important.

Developing and diversifying manufacturing in NZ would have many co-benefits, such as:

- Hedging against downturn in globalisation and strained supply chains
- 3D printing can catalyse cheap export of designs
- Reduced carbon footprint of transport miles
- Provision of high skilled local jobs

Economy & Finance

Resilience Options

- The Reserve Bank should analyse the scenario of complete national collapse of payment systems (eg, offline digital currency, manual processes, physical cash, orderly closure of financial institutions).
- The government could plan for how to financially support industries essential for survival in a GCR, and how to ensure people can pay for food.
- Downward counterfactual analysis of past events (eg, how could Cyclone Gabrielle, or the Christchurch earthquakes have been worse) could help with preparations.
- Moving towards a circular localised economy could help resilience and trust.

Context

Finance, economics, revenue, and insurance are intricately interrelated, and dependent on digital systems. There is most likely a lack of actual paper money to support a paper-based economy. Under a moderate catastrophe the government would need to ensure some means of trade was supported. Under a severe scenario people may not value paper money (or any money) and fuel and food become the only items worth trading. A narrative of solidarity/cooperation despite a no cash economy might be needed.

DPMC's list of Nationally Significant Risks includes economic crises such as 'commodity or energy price shock', 'financial crisis', 'major trade disruption', and 'armed conflict'. Although as mentioned elsewhere in this report, the scale and scope of disruption contemplated generally falls short of GCRs.

We've written previously that an operational financial system in NZ could be threatened by nuclear war, with a risk of collapse. Unemployed and retired people would need money to buy food from farmers, food processors and food distributors. Therefore, central, and local governments might need to have backup food rationing systems and systems for prioritising food supplies to essential workers and those at greatest need. Fortunately, the NZ Government obtained some valuable experience with rapidly providing mass welfare support during the Covid-19 pandemic—but the scale of a post-nuclear war situation would probably be vastly greater and longer lasting. Appropriate financing may also be needed to assist the agricultural sector to optimise production the new circumstances.[138]

NZCat workshop participants concluded that the impact of a Northern Hemisphere nuclear war/winter on NZ could exceed NZ$1 trillion in monetised consequences.[139] But even that assumed that certain systems keep operating, like social cohesion, digital systems, availability of cash, and so on. There would be impacts on banks and the stock market, the prices of assets and goods would change overnight. A national economy might cease to exist.

The recent McGuinness Report on the 1980s NZNIS stated that, 'For the financial and monetary system, a set of procedures should be agreed for maintaining or replacing electronic systems, guaranteeing deposits, maintaining adequate cash for people's needs and adjusting assets and liabilities in an orderly fashion. This should reduce the danger of sudden collapse in the financial system and retain a capacity to assist rather than impede adjustments in production, employment and consumer demand.'[140]

The 2023 NZ Lifelines Council Infrastructure Vulnerability Assessment included a new brief discussion of 'financial market infrastructure,' with 'cash payments' being left for a future iteration. The report notes that the payments sector is in many ways becoming *less resilient*.[141]

If digital payments fail, then physical cash might be needed. The Reserve Bank wants resilience built into the cash system and is chairing an industry forum with banks and cash-in-transit providers looking at the cyclone response and lessons learned. This programme should include a GCR lens. Offline digital currencies, and stored value cards are possible resilience options. These would probably be far more cost-effective than government stockpiles of metal coinage.

Insurance could be problematic. The private sector cannot offer insurance against existential risks due to their scale and unpredictability. Examples of limited insurability include pandemics, which are deemed too widespread, severe, and unpredictable, and terrorism involving chemical, biological, radiological, or nuclear weapons.

NZCat survey and interview respondents with economic expertise identified the following issues:

- The country is unprepared for this kind of catastrophe (and national risk information is not public), NZ faces 'chain reactions', but society would likely adapt. However there needs to be a serious focus on the resilience of payment systems, food, and fuel. The 'initial shock' will be a big problem and lessons might be drawn from Covid-19, the Christchurch earthquakes, and Cyclone Gabrielle. In Covid-19 a centralised response worked relatively well and DPMC needs to plan for a major global catastrophe – there needs to be more awareness across government and in the community.
- However, some interviewees criticised an overly centralised response and noted there is need to engage with businesses/public. Multilocation preparedness is needed in case of centralisation failure and regular serious gaming by local leadership in anticipation could help.
- If there is failure of ICT (as detailed in 'Digtal/ICT' above) this could result in severe collapse of economic activity. An offline digital currency might be needed, or cash reserve. Decentralised autonomous organisations (DAOs) could help shift funds. IOUs could be a short-term solution, but these are susceptible to fraud/lack of trust. An orderly closure of financial institutions might be needed and should be planned for. Manual recordkeeping could be needed. The impact of a loss of electronic backup could have a decades long impact.
- The Reserve Bank should analyse the scenario of collapse of payment systems. Cybersecurity work needs to include contingencies should defences fail. If critical economic systems breakdown in year one there could be catastrophic civilisation collapse. Downward counterfactual analysis of past events could help with preparations. Moving towards a circular localised economy could help resilience.

Border Issues

Resilience Options

- Determine how many catastrophe refugees NZ can/will welcome and prepare for this number (calculations of food calorie supply in the anticipated context should be completed).
- The NZ Government should have criteria for:
    - When to close the border and how
    - When/whether military should be used internally, or just police?
- Establish protocols for sophisticated use of quarantine (eg, offshore islands, especially in the case of bioweapon use).
- Deploy naval and autonomous drone units providing surveillance; however, military technology may be prone to a range of the barriers to maintenance identified above.
- Alliances among resilient island nations ahead of a catastrophe might secure trade resilience, prevent migration, and discourage attack (eg, Indonesia, Australia, the Philippines, and NZ).

Context

In the wake of a nuclear war, NZ might face a complex array of issues pertaining to border security, immigration, refugees, and defence. These problems include a potential influx of refugees, the possibility of armed arrivals.

Refugee Influx and Immigration: A nuclear conflict in the Northern Hemisphere may spur a rush of refugees to NZ, comprising of residents living abroad, tourists stranded in the country, and individuals from Pacific Island nations facing economic difficulties. This potential mass arrival could overwhelm the nation's resources, risk spreading diseases, and cause social disorder. A well-articulated plan to manage these issues is necessary. NZ should consider strategies for managing refugee influx, including quarantine measures and calculations of food carrying capacity.

Border Security: A post-nuclear scenario could make NZ a target for governments and non-governmental groups seeking resources. NZ's vast coastline would necessitate extensive surveillance, potentially using technologies such as drones, to secure its borders.

Defence Context: NZ's defence forces are currently more focused on humanitarian help and enforcing laws, rather than defending the country itself. However, NZ is currently going through a period of repositioning from a defence point of view with movement towards a strategy of asymmetric hedging of relations between China and the US, which includes investment in new capabilities such as advanced Poseidon aircraft, and invitation to Pillar II of the AUKUS Alliance. NZ should evaluate its diplomatic stances in the context of changing military alliances, through a GCR lens, and consider investing in advanced defence technologies to maintain compatibility with key military partners and its existing military alliance partner: Australia. Cooperation with resilient island nations ahead of a catastrophe could also secure trade resilience (eg, protecting against piracy) and discourage attacks.

Planning for border issues will have co-benefits for NZ, given increased immigration due to climate change, whether there is nuclear war or not. Preparation for unwanted arrivals would have benefits for extreme pandemics as well.

Yet the risks may not be as great as some might think. Elites that control limited resources may stay put in other countries, and ordinary citizens couldn’t travel in great numbers if commercial transportation is degraded. Historical data indicates that out of the various attempts of refugees in boats heading to Australasia, none have reached NZ.[142] Somewhat paradoxically, a particularly severe

nuclear war/winter might make arrival/invasion less likely (or impossible) amid widespread devastation, food and fuel shortages, or disabled industry.

Health Security

Resilience Options

- Build on Covid-19 success and grow NZ's score against benchmarks such as the Global Health Security Index, including resisting novel infectious threats (bioweapons, engineered pathogens).
- Conduct a bioweapon scenario walk through and red-teaming of response plans.
- Consider developing an offshore quarantine facility (eg, if bioweapon use and refugee arrival).
- Develop plans for rationing medicines and stock take/requisitioning all stocks to distribute justly (if not agreed ahead of time, then disputes could hinder implementation).
- Cooperate with Australia on medical/medicine manufacturing to complement the range of products available.
- Invest in a national Public Health Agency as part of ongoing health reforms.
- Consider training a 'health sector' reservist army (people trained to do first aid, basic nursing, healthcare assistant duties, if surge capacity is needed).
- Educate the public about the lack of likely impact of radiation, but potentially high UV levels.
- Ensure a reliable supply of clean water for drinking (see 'Water' section above).
- Consider developing NZ manufacturing capability for human vaccines (could plan to pivot the existing animal vaccine industry or collaborate with Australia).

Context

A Northern Hemisphere nuclear war/winter could cause far-reaching impacts on health. In many parts of the world there could be mass hunger and starvation. There is the possibility of epidemic/pandemic disease, particularly if bioweapons have been used. Medicines and urgent care could be in short supply.

Protection from infectious diseases and pandemics will be particularly important as these could risk further undermining fragile socioeconomic systems. Key factors will be public health, sanitation, nutrition, vaccines against pandemic diseases, medical stockpiles, and quarantine facilities for refugees. With a no-trade scenario, rationing of healthcare might be needed.

The NZ Infrastructure Commission's 'State of Play' report on the NZ Health System found it to be characterised by poor asset management, likely undermining health outcomes.[143] There have been historic deferrals of maintenance and workforce retention and attraction problems. The Covid-19 pandemic highlighted the need to plan for future catastrophes.

In the context of a Northern Hemisphere nuclear war, the health system may suffer from inability to access medicines (which could severely affect a minority of people) and equipment needed for the practice of healthcare and for maintenance. Arriving refugees could bring diseases if biological weapons have been used elsewhere or epidemics are triggered by the war.

However, it must be noted that the key to broad population health in an extended global catastrophe will largely hinge on ensuring access to clean water, appropriate sewage disposal, a sufficient food supply, non-pharmacological management of communicable diseases, and potentially vaccines if there are epidemics of disease associated with the catastrophe.

Investment in health security ahead of any catastrophe could be guided by validated tools such as the Global Health Security Index,[144] and would have day-to-day wellbeing benefits, as well as mitigating the impact of future epidemics/pandemics.

Social Response & Governance

Resilience Options

- Ensure policy proposals put a cooperative narrative at the forefront.
- Conduct citizen assemblies or similar deliberative democratic processes to inform planning and prioritisation for the aftermath of a global catastrophe.
- Government should consider communication strategies to get everyone onto the same page, as cohesion will be important.
- Central government should plan for an initial coherent, reassuring, yet realistic response, but also plan for its own failure and devolution to local government.
- Ensure there is realism about a lower standard of living.
- Consultative processes should be established to formulate principles of resource allocation, with a focus on local governance.
- Improve the capabilities of local government prior to catastrophe, including the ability of local government to raise its own revenue (eg, via fuel taxes, a % of GST or local land taxes going to local government).

Context

The 1980s NZ Nuclear Impacts Study noted that there is no precedent for the societal response in NZ to a global catastrophe. Information would be sought, and complete and detailed information is more likely to be accepted than information filtered to 'avoid panic'. There will be feelings of loss, trauma, fear, and dislocation. There could be tension between official duties and family life, and business closures or absenteeism.

Organisations that people look to for help may be significantly disrupted. Urban dwellers might find disruptions particularly difficult. People will focus on their immediate needs and will look to government for assurance that those needs will be met. But people will likely take the initiative in the absence of centralised governance. Three (non-predictive) models of how government might respond, and the possible consequences were proposed. These were panic and breakdown, a centralised repressive response, and a flexible regional response. Failure of an initial coherent, reassuring, yet realistic response from government would be a significant threat multiplier.

The appropriate role of central and local government after nuclear war is not clear. As a contingency, central government needs to plan for its own failure. There may not be sufficient time to react at scale, so preparation and planning are important. Prior social engagement and broad agreement on issues such as resource allocation are probably essential, especially given the risk of hastily made decisions with imperfect information or advice. It is conceivable that central government might assume 'draconian powers' over an unruly, unlawful populace; but alternatively cooperative responses and power-sharing arrangements, possibly at regional scales could occur. Orderly devolution of greater power and more resources to local government may be ideal.

Someone with extensive pre-briefing quickly needs to be put in charge of the response, declare an emergency, have appropriate powers, with effective layers below. But the response should not be driven by central government alone. The enquiry into the 2023 Auckland flood response is telling:

> 'Rather than a model based on central planning and localised delivery, the Council's emergency response was premised largely on centralised coordination and delivery of response. In the event, this weakened the localised intelligence flows that could have supported better targeted community responses.'[145]

This is exactly what could happen after a global catastrophic event as well. Central government might expect to keep control of events and delivery rather than having a strategic approach to handle multiple crises with regional/local/iwi delivery of key responses.

Local community resilience to major global catastrophe could be increased by strengthening local organisations of all kinds. For local entities to act they need appropriate risk information from central government, for example a detailed entry on nuclear war/winter (and other catastrophes) in a National Risk Register. Crucially, local entities need to understand that such a National Risk Register is targeted at them as well as central government. Key will be ensuring that communities have basic capital resources ahead of time. Regionally, people need to know the rate at which they can use commodities like imported liquid fuel, and what needs to happen in the months until it is used up, to ensure sustainable food production, transportation, local distribution, and so on.

Coordinating people after the fact will depend on functioning communications (see ICT/digital section above). There should be a plan for Government communications to fail. In such circumstances how will rationed goods like fuel, medicine, food, be distributed? The entire population may suddenly lose their personal online services such as email, messaging, video calling, photos, documents, banking, social media, ride sharing, maps, the internet. It will be important to maintain a broadcast capability (long and short wave) and receivers, such that people can obtain information. Devolved local coordinating mechanisms, and community-led resilience leadership and collaboration need to be supported. Communities that work together to look after each other will do better than those that don't.

NZCat workshop participants reiterated the above concerns. Fuel security and food supply are the most likely drivers of social unrest. In extreme situations there is a tendency for groupings to work in their own (perceived) self-interest. There were regional road blockades during the Covid-19 pandemic and this kind of activity could occur again. There is also a risk that any planning is seen by a small active minority as part of a plan of government control. Emergency response experts thought that avoiding or reducing the likelihood or distribution of disorder is much more about ensuring communities can support themselves and receive basic resources, rather than imposing order. Hence the need for planning.

The Government could lose 'social licence' if deprivation increases and falls unevenly between urban/rural areas and communities start to shift into survival mode. The Golden Triangle of Auckland/Hamilton/Tauranga with the largest concentration of population and economic activity, and biggest demands for food, water, energy, might see the build-up of a 'mini-diaspora' as people are forced out of the cities to seek food.

Key questions remain, including how would decision-making be most pragmatically determined – centrally or regionally? What roles would be relevant for Civil Defence, iwi and marae-based organisations? How would this happen in the case of communications collapse/reliance on international data connectivity? A better understanding of this is needed.

NZCat expert survey respondents noted the risk of mis/disinformation in the aftermath of a nuclear war. Political leadership would be important, but power politics would be a risk factor. Any prior efforts to enhance social cohesion and political stability would be valuable. Cross-party/bipartisan

planning would be ideal. So too would be efforts to strengthen real-life communities and create 'a community of community groups'.

A well-communicated plan to prioritise essential functions, ensure sufficient food supply, and then to distribute resources equitably, made prior to a GCR, might be the best defence against disorder. Local and regional government should be forming partnerships ahead of time with the rural food production sector, and transport sector, for crisis preparedness. Central government should have plans in place to devolve power to local government. Resilient communities that are well prepared with strong social networks will do better than others without these pre-existing resources. Subsistence and survival may require local solutions.

NZCat interview participants identified a distinction between labour *availability* and *willingness*. Personal and family concerns could initially take precedence over work incentives. However, after the initial shock, the establishment of a functioning labour market could restore a semblance of pre-impact order and social cohesion. If conserving fuel, work in agri-food production could provide primary employment as society adjusts to a 'new normal'. Coordination across members by organisations like the Food and Grocery Council and supermarket chains (as with Covid-19) would be essential, and planning would be ideal. However, expert interviewees also noted that while anticipatory scenario work could be beneficial, compelling private companies to engage might prove difficult. The situation calls for shared responsibility and information exchange between government and industry, supported by interdepartmental coordination and appropriate incentives.

Cooperative Narrative: More resilient societies have strong shared identities, with resilience built into people's mindset, and it may be useful for NZ to put this at the forefront of any policy proposals and paint a powerful vision – including through using various means of communication, to motivate both policymakers and the community. The compelling narrative must be to try to emphasise the importance of social cohesion to societal resilience. Cohesion can be prepared ahead of time, but it can break down if there is real or perceived threat to basic needs like food and water supply. It will be important to study which factors might be touchpoints that lead to unrest. Looting is more likely in situations of low trust and high inequality. Hoarding is more harmful in situations of high inequality.

Legal & Regulatory Issues

Resilience Options

- Consider introducing a US-style Global Catastrophic Risk Management Act to mandate assessment and resilience options for GCRs including nuclear war/winter
- Define, identify, and regulate critical national infrastructure, including infrastructure that might be needed for resilience to GCRs including nuclear war/winter (but does not yet exist)
- Ensure legislation, such as the Emergency Management Bill of 2023, provides the appropriate wide-ranging powers for effective response (including strengthened legal powers for local government)
- Revise present laws so they don't obstruct community-level resilience and planning for GCRs

Context

Disaster risk reduction in NZ is informed by the UNDRR Sendai Framework for Disaster Risk Reduction. The UNDRR conducted a mid-term review of the Framework concluding that the Covid-19 pandemic has shown that 'prevailing risk governance and risk management architecture, mechanisms and approaches are inadequate when dealing with systemic, interconnected drivers of risks and cascading impacts that can spread within and across human and natural systems.'[146]

Additionally, recent UNDRR actions indicate a shift to more concern with GCRs, as evidenced by the Simon Institute's report on 'Existential Risk and Rapid Technological Change' that was commissioned by the UNDRR and focuses on biological threats and risks from artificial intelligence.[147]

Following the 1980s NZNIS, a Law Commission Report (1991) addressed nuclear war specifically, considering what executive powers are needed and justified to deal effectively with a national emergency in NZ, in a manner consistent with our basic constitutional system and traditions. The report noted that a nuclear event, whether arising from a nuclear war or a nuclear accident, could have a drastic impact on NZ and as with war, the consequent threat to the life of the community would call for the granting of wide authority to the executive.

Other countries have begun to address GCRs directly, for example the United States through the Global Catastrophic Risk Management Act 2022 and the UK has implemented a Government National Resilience Framework as well as their 2023 National Risk Register, which includes some GCRs. NZ could replicate these kinds of actions (see 'Risk Management' above).

NZ's risk management framework addresses various risks (see Risk Management above), including some of those with potentially catastrophic consequences. This framework emphasises proactive risk assessment, planning, and response, and includes:

- Hazard identification and risk management through the National Emergency Management Agency (NEMA) (previously) Ministry of Civil Defence & Emergency Management (MCDEM).
- The Civil Defence and Emergency Management (CDEM) Act 2002
- National Security and Risk Assessment
- National Risk Register (confidential)
- The Emergency Management Bill (2023)
- Climate Change and Environmental policies including the Climate Change Response Act 2002
- International agreements and collaboration

However, the existing CDEM Act definition of lifeline utilities has a much narrower focus than other international definitions. Some of this is being revised in the Emergency Management Bill 2023, although mostly through tweaks to the 2002 Act, without listing what the critical infrastructures are. NEMA's summary of changes in the Bill notes that only the National Fuel Plan currently ticks the boxes needed, but as we noted earlier in this report, even this plan doesn't appear complete, as it doesn't quantify fuel needs, nor how to supply them, for survival essential sectors, such as on-farm agricultural machinery, across months or years of possible isolation.

DPMC's critical infrastructure resilience regulation consultation may begin to address some of these issues. However, there is scepticism and a Radio NZ analysis of OIA documents on resilience obtained following extreme weather events in early 2023 suggests that substantially more work is needed. This work includes that on vulnerability assessments, and infrastructure resilience, with law changes being needed to give government any sort of power to implement improvements.[148] One weakness of current approaches to critical infrastructure is that they are focused only on presently existing infrastructure that has been deemed critical, rather than on infrastructure that might be needed for essential functions or even survival under certain catastrophe conditions, but which does not yet exist. For example, onshore cloud computing to support logistics, coastal shipping should road trucking collapse, or biofuel production to fuel shipping or agricultural machinery in a protracted global catastrophe. There will be many other examples across other sectors.

Māori

Resilience Options

- Formally investigate fruitful convergences among Māori economy, marae, GCR resilience, and community needs.
- Strengthen linkages and capabilities between national and local government and marae and iwi in the face of potential catastrophe.
- Conduct research into the relationship between shared traditional and national values, such as wellbeing of future generations, and GCR resilience.

Context

Our project did not have resourcing, or expertise to specifically examine links between Māori and GCR resilience. However, this is an important area for future work. That said, NZCat workshop participants noted that Māori contributions to national resilience in the face of GCRs are already immensely important. It is crucial to include Te Ao Māori and Te Tiriti obligations in this conversation (for this impact category and more generally).

Additionally, the Māori economy is very developed and could drive many of the resilience options described in this report. A Māori world view could be a significant asset and there is the possibility of traditional 'no tech' approaches to many problems. It could be that Māori integration in economic resilience offers opportunities for collectivism and resilience with a focus on communities as a whole, examples of this were seen following the Canterbury Earthquakes.

When disasters hit, often the first responders organise their communities from the local marae. Also, iwi were a link between central government and what was happening on the ground locally.[149] Marae are an integral part of civil defence infrastructure, and so development of marae resiliency and capabilities to help would be beneficial.[150] A valuable existing resilience measure is Māori community gardens.[151] On the other hand, some Māori reside in deprived communities or localities that are exposed to hazards (eg, at risk of flooding). This needs to be recognised in resilience building and planning.

There are important connections between Māori and the core sectors discussed above. In 2023, the NZ Infrastructure Commission noted wider Māori involvement in infrastructure including ownership, investment, partnership, and participation.[152] The Commission has previously noted that, 'Māori have fundamental interests in the energy sector due to the role of natural resources in their culture, values, and worldview (Te Ao Māori). Māori knowledge (mātauranga Māori) is embedded in the relationship between people and natural resources, often connected with their kinship (whanaungatanga).'[153] Also, Māori intergenerational views lead naturally to a strong focus on sustainable business practices to ensure future generations enjoy the benefits of the natural resources they are using today. These facts converge in important ways with resilience to global catastrophe. One energy expert interviewed by NZCat noted that mātauranga Māori is a key cultural advantage that could shift thinking away from industrial 'solutionism' were the cultural concepts from Te Ao Māori that speak of hard constraints on human activity related to the natural environment to be incorporated.

With respect to trade and supply, we note that the proposed Southern Link trade route has a large focus on Māori trade. There will be many other important connections between Māori and GCR resilience. These are beyond the scope of this initial report but should be examined collaboratively with Māori and in detail.

PART D: Cross-cutting themes & existential risk

Image credit: MidJourney

Study Themes for a Policy Agenda

This report shows that NZ, under business-as-usual, would likely face severe impacts across all sectors in the event of a Northern Hemisphere nuclear war/winter or similar global catastrophe. Failure of densely interconnected systems appears inevitable. These include, but are by no means limited to, disruption and failure of essential services, energy systems, transport, supply chain, ICT, economic impacts, food insecurity, and socio-economic instability.

There is no single solution to this kind of catastrophe, and mitigation, whether preparation or response, would most likely focus on limiting the harm. However, expert stakeholders clearly regarded planning to be better than no planning, emphasised the need for overarching and integrated governance of GCRs, and suggested a range of national plans, strategies, investments, and coordination exercises that might significantly improve resilience after-the-fact.

Cross-cutting Themes for Aotearoa NZ Resilience

The 'resilience options' detailed at the start of each sector section in the report above should be evaluated by stakeholders and decision makers, compared through cost-effectiveness analyses, and promising approaches deployed. In addition, those tasked with risk management should attend to 10 cross-cutting themes identified by the NZCat project (Box 22).

Box 22
10 Cross-cutting themes for Resilience to Nuclear War/Winter & other GCRs
1. **The main problem of GCRs** is that complex interdependencies in modern societies mean failures in one region, sector, or system will cascade to impact many sectors/systems
2. **The main solution** is strengthened catastrophic risk governance to undertake systematic all-hazards risk assessment, foster international coordination of cross-border risks, and undertake comparative cost-benefit analysis and national resource prioritisation
3. Investing in capital stocks including natural capital, human capital, physical capital, and social capital relevant to global catastrophe will increase preparedness, response, and recovery post-catastrophe, and enhances societal resilience to other risks.
4. Government, industry and communities must plan together and share risk information openly to empower strategies, plans, and frameworks for resilience
5. First steps towards global catastrophe resilience should ensure NZ's ability to provide basic needs like food, water, sewage disposal, fuel, transportation, and communications in the context of extended trade isolation
6. It is good to ensure existing critical infrastructure is *resilient*, but NZ needs more assessment of what alternatives might be needed to allow for new ways of doing things after a global catastrophe, *resilience* infrastructure might be needed as insurance
7. Cooperation will be needed to weather global catastrophe, and national narratives should ensure that people know what the risks entail and that collaborative solutions are possible
8. Communities and local governments have a key role to play in resilience to global catastrophe, especially if transport and communication are degraded, but communities need risk information and resources to develop local solutions
9. NZCat heard diverse concerns about global catastrophe, but also diverse ideas for building resilience. More research and engagement are needed to systematically compile and evaluate these proposals
10. Initiatives that develop resilience to nuclear war will almost certainly have benefits in case of other global catastrophes, local hazards, for business-as-usual, and the security of the human future (value for money assessments must account for all these benefits)

1. Complex interdependencies & cascading consequences

The main reason why nuclear war and other global catastrophes are such a risk is that human systems are complex adaptive systems embedded in complex adaptive ecological systems and harms to one system cascade to cause harms in all systems. NZ's systems are embedded in global systems, and some of these global systems are critical to NZ's functioning. Sectors are densely interconnected and interdependent. Risk is systemic in nature, and hazards manifesting at critical global pinch points (eg, a massive volcano near the Luzon Strait, or a military blockade of Taiwan),[154] or in critical systems, can have outsized impacts. GCRs like nuclear war/winter could severely disrupt both human systems and ecological systems with dire and unpredictable cascading consequences.

Repeatedly, studies of the impacts of nuclear war have concluded that the interconnectedness of sectors such as energy, transport, food, and communications mean that should one fall, all are at risk, in a cascade of catastrophe. This was the main finding of the 1980s NZ Nuclear Impacts Study, and information from expert stakeholders in 2023 reiterates this finding. If anything, the interdependencies, and therefore the risk, is greater today.

The scale and complexity of global catastrophic risk, such as nuclear war/winter, means that deliberate and internationally cooperative governance is almost certainly necessary.

2. A need for governance of catastrophic risk

The main solution to the above problem is specific governance, responsibility, and accountability mechanisms to ensure that key actions that mitigate the threat of global catastrophe are taken. Gaps in current risk management approaches, and a lack of long-term planning, mean that GCRs like nuclear war do not receive the attention that their likelihood and consequences justify.

NZ needs a coordinated and anticipatory approach to major cross border global risk. This approach should include systematic analysis of risk, strategies for building resilience, response plans and support for cooperation across government, industry, and communities.

A high-level entity must be tasked with this coordinated approach, and such an entity should be supported by legislation mandating regular systematic risk assessment, including GCRs, and advice to a cross-party/bipartisan parliamentary committee tasked with a system-wide and long-term view, operating outside of the day-to-day demands of government. Legislation is required to ensure that the right people and organisations can come together to work on the right problems/plans at the right time, and that these cover the foreseeable emergencies.

A systematic all-hazards approach to risk

The present study focuses on Northern Hemisphere war/winter as a representative GCR, to illustrate the scale and scope of the risk. But there are many more potential global catastrophes (see Appendix B), some are very unlikely, others not so unlikely, each has unique features, and across the set there are commonalities. It is only by undertaking a systematic assessment of nationally significant risks, that includes this set of GCRs that a true assessment of collective likelihood and expected consequences can be completed.

Additionally, a systematic assessment is needed to develop and provide the public sector, businesses, and communities with risk information. Risk information is needed to foster a shared mental model upon which preparation and response actions can be based. More engagement, more awareness, and more crowdsourcing of solutions is needed, because government will not be able to manage

GCRs by itself. A systematic, publicly facing, transparent, national risk assessment and risk register would provide a common vocabulary for resilience action.

International coordination, especially with Australia

No single country can mitigate global catastrophe alone, so a cooperative approach is needed. National risk assessments have traditionally focused on internal nationally significant risks, rather than cross border risks, but major catastrophes such as nuclear war, may originate elsewhere, and spread to affect NZ. However, when cross-border risks are compared in different national risk assessments, different countries assess their salience differently.[155] A key step would be to collaborate on the assessment of cross-border risks.

In NZ's case, the most critical variable in GCRs appears to be the threat of trade isolation. It will be important for NZ to coordinate with regional trading partners ahead of time to ensure available trading infrastructure in the likely context post-GCR. Cooperation with Australia seems potentially critical and planning to facilitate trade could help alleviate issues across food, transport, energy, and ICT/digital disruption.

Cost-benefit analysis & prioritisation

Cost-benefit analysis (CBA) is essential to ensure that resources are directed to resilience initiatives that are effective and provide the best value for money. Two major issues prevent optimal risk management under the current approach. Firstly, there is no individual or organisation responsible for assessing and reporting the likelihood and consequences of major cross-border global risks and their significance for NZ. This means that important risk information that might materially impact CBA is overlooked. Secondly, current risk management occurs in silos where those working on risks tend to see only the risks they are familiar with. This means that any CBAs undertaken may not be compared across the suite of risk initiatives.

A systematic national risk assessment identifying hazards, threats, and consequences, would identify common consequences, aggregated likelihood, as well as uncertainty, and include all the actual risk. An integrating mechanism, looking across all risks (including GCRs) could then undertake CBA on the suite of proposed resilience measures, and prioritise and resource the most cost-effective up to the budget for risk mitigation (Box 23). The budget for risk mitigation would be set by considering the opportunity cost (and cost-effectiveness) of marginal spending on other programmes (another kind of formal prioritisation).

Box 23: Resilience Nugget

Cost-effectiveness and Expected Value of Risk Mitigation Activities

It's not obvious that rebuilding the same infrastructure, even to a higher standard of resilience, is the best use of limited resources. It's also not clear that placing responsibility for national resilience in private (even well regulated) hands is the optimal resilience strategy. Government investments may be warranted.

Two key factors need to be considered when prioritising resources for building resilience

- **The expected harm caused by catastrophe and the expected value of mitigation actions.** For example, Covid-19 caused approximately 20 times more deaths than all other natural disasters in the period 2000–2023 combined (this includes the Boxing Day tsunami 2004 and Haiti earthquake of 2010). Mitigating the impact of human pandemics by even 10% might have benefits beyond all other natural hazard risk reduction activities. This does not mean we should stop building resilience to natural hazards, but it underscores the importance of adding actions directed against global catastrophes as well, especially where modest strategic investments in resilience planning and infrastructure have high expected benefits.

- **The aggregate likelihood of consequences across all global catastrophic risks.** Many global catastrophic risks have a similar consequence profile (for example, through their impacts on trade, supply chains, climate, and so on). If global catastrophic risks are examined in aggregate, the likelihood of these impacts is much higher than when hazards are assessed individually. This means that calculations of the cost-benefit of resilience activities is multiplied, underscoring the need to assess global risks systematically, as a set, rather than individually in disciplinary silos.

3. Capital stocks approach to extreme risk

The role of central government might be largely in anticipating catastrophe and ensuring that the capital stocks of NZ are sufficient for regions and communities to effect recovery. This is because it is possible that the extreme impacts of the nuclear war scenario mean that central governance is not feasible after the fact. Additionally, severance of connectivity to the world could leave NZ with unmitigated dependencies.

Capital stocks include natural capital, human capital, physical capital, and social capital. These resources, know-how, material goods, institutions, organisations, and norms provide a foundation for recovery, preventing societal collapse.[156]

It is important that NZ identify critical resources and critical infrastructure, define them so they are captured by regulation ensuring their resilience and availability after the fact. The expert stakeholders consulted in this project identified many critical infrastructures such as ICT/digital technology, including cloud computing, and transport infrastructure such as coastal shipping, or liquid fuels. These are all discussed above. It will be important that critical resources are accessible by communities in the context of a GCR.

One critical factor identified by expert stakeholders is ensuring that NZ has a sufficient pool of appropriate talent and expertise to ensure not just planning, but response, and resilience. NZ should make every effort to nurture and retain this talent and expertise.

4. Planning and cooperation among government & industry

The NZCat project identified a recurring theme of cooperation and the need for collaboration between industry and government. Interaction between risk and resilience specialists and senior leadership was identified as important in the face of global risks. Experts said there was not yet enough scenario work, walk-throughs, red-teaming response plans for weaknesses, or simulations of global catastrophe. It was revealing that even the risk assessments MBIE commissioned on liquid fuel supply did not contemplate GCRs, and commercial entities engaged for that work refused to speculate on such impacts.[157]

This all seems at odds with a 2023 Green Paper produced for Business NZ called 'We're All in this Together',[158] which asks how business and government can collaborate to address shared challenges. The report recognises an uncertain ecological and geopolitical environment and lack of coherent long-term approach. It advocates political bipartisanship to ensure security and certainty. The report recommended much greater focus on effectiveness and value for money of policies. We note that when it comes to resilience, investment up front is often extremely cost-beneficial, but a systematic assessment of risk (as recommended above) is needed to map the space of potential investments systematically, to ensure the most cost-beneficial can be pursued. Recent trends toward resilience over efficiency might lead industry to prioritise resilience options in this report, for example energy efficiency, stockpiling of critical components and industrial inputs, or better still, localisation of supply chains, enhanced digital redundancy and security, and resilient communications.

NZCat collated a list of national plans, strategies, and frameworks the expert stakeholders recommended. Working groups representing government, industry and communities could be organised to develop these plans (Box 24).

5. Ensure provision of basic needs

There is a distinction between 'essential services' such as communications, public transport, or banking services, and actual basic survival needs such as water, food, and shelter. Planning for global catastrophe should start by ensuring plans to provide basic needs in the kinds of protracted scenarios described in this report. This means auditing vulnerabilities in basic systems to failures in fuel and energy supply, transport, digital and ICT services, international trade, and supply of expertise, that extend across months or years. How can the necessities of life be provided at population scale in such circumstances? NZ could consider legislating that such analysis and planning be regularly conducted, considering the full spectrum of GCRs. The United States provides a template for this in their Global Catastrophic Risk Management Act 2022.

6. Both resilient and resilience

Ideally, NZ would seek to nurture a (relative) degree of national self-reliance and secure infrastructure across all sectors, including a Plan B. Mitigation of global catastrophe is not just about ensuring that business as usual is robust to perturbations, it is also about developing a 'Plan B', investing in options to pivot, or adapt, and alternative ways of supplying basic needs. We need both *resilient* infrastructure and systems, which we currently depend on, and *resilience* infrastructure and systems (that can provide when core systems fail).

Programmes to identify NZ's critical national infrastructure,[159] and to assess its vulnerability,[160] need to define, identify, and assess not just how *resilient* existing infrastructure is, but also what *resilience* infrastructure might be needed, and ensure it is developed. Critical infrastructure needs to be *resilient* to natural hazards, or malicious threats, but we also need infrastructure to ensure NZ's *resilience* to extreme scenarios like nuclear winter or trade isolation.

This resilient/resilience distinction is clearly illustrated by the need to ensure liquid fuel supply from overseas can continue, while also having a backup plan to supply liquid fuel (eg, biofuel) locally in times of global trade collapse. A Marsden Point terminal robust in the face of tsunami threats, along with weeks of stored onshore fuel supplies might be *resilient*, but the ability to pivot and produce a minimum quantity of biofuel at a canola oil refinery engineered for this capability, would provide *resilience*. All sectors should audit their resilient/resilience capabilities.

Box 24: Resilience Nugget

National Plans, Strategies, and Frameworks recommended to NZCat

- Legal/Regulatory arrangements
  - Statutory basis for National Security Arrangements
  - Clear and appropriate definition of critical infrastructure (that includes essential digital services such as cloud computing or mobile communications, as well as neglected infrastructure such as coastal shipping)
  - Legal provisions to maintain democracy
  - Changing procurement rules to encourage local solutions
- National Risk Assessment
  - Publicly facing National Risk Register
- National Resilience Framework
- National Technology Investment Agency
- National Chief Technology Advisor
- Pre-disaster strategies
  - National Risk Strategy
  - National Energy Security Strategy
  - National Food Security Strategy
  - Digital Infrastructure Resilience Strategy
  - Long-term Supply Chain Strategy
- Catastrophe response plans:
  - National Fuel Plan
  - Contingency Plan for Major Technological Outage
  - National Digital Communications Continuity Plan
  - Reserve Bank Plan for No Digital Payments
  - Zero-trade Plan
  - Strategy for Re-establishing Trade with Australia
- Long-term recovery strategies
- Plan for physical knowledge repositories

7. A narrative and vision of resilience

It is important that people understand that solutions are possible and understand this ahead of time in case communication is not possible after a catastrophe. In the face of global catastrophe, despair is a common reaction. Several of those engaged throughout the NZCat project expressed a view perhaps summed up as, 'we'd all be f*#cked'. Yet, optimistic visions and plans for mitigation of

global catastrophe have been proposed worldwide, including for example, food security plans in the face of extreme sunlight reduction.[161] It's possible that one very cost-effective approach to nuclear war/winter is simply to develop a narrative of cooperation and resilience, illustrating stories of what success looks like, that emphasises that increased community resilience generally could increase GCR resilience specifically.

8. Community and regional resilience

A prominent theme through various engagements in the NZCat project was the need for community-level resilience as a critical asset and backstop in catastrophe. Not everything can be planned centrally, and in a global catastrophe connectivity, whether communications, transport, or trade could be lost. When all of NZ is impacted at once, there may be no 'outside' help. Local networks and communities need to have a level of self-sufficiency, but this needs analysis (how much food production potential, how much fuel, medicine, for how many months/years, where, how to access it?) and it also needs investment.

Government in NZ (central and local) could support these measures by implementing initiatives such as: citizen assemblies to discuss rationing plans; or support for community resilience and response initiatives including promotion of food security initiatives; support for investment in diverse and resilient forms of energy; legislation or policy to encourage more resilient and locally nested ICT/digital and communications systems; establishing a centralised/cross-sector community human resource system to call on in crisis events; and encourage relevant stockpiling and localisation of supply chains, among other initiatives.

9. Further research and evaluation

There are necessary limitations to our study. This NZCat report is certainly not the last word on Northern Hemisphere nuclear war/winter and NZ's vulnerability and resilience. In fact, we hope it is a new start to the discussions, along with the excellent NZ Nuclear Impacts Study of the 1980s. We are a relatively small team, some are volunteers, and we worked within a limited timeframe. We consulted diverse experts, but there are many more out there. We did not have the resourcing to conduct community engagement or Māori engagement. All these are important future tasks.

The NZCat Hazard Profile shows that the threat of nuclear war is particularly salient, but so are the risks posed by other potential global catastrophes. There is an opportunity to develop a National Science Mission or think tank that addresses these extreme risks. Much more research and analysis are needed, as we have identified in the sector reports above.

NZ is remote and safe from certain kinds of risk, but its extreme dependence on the outside world is a critical vulnerability, and we need more understanding of how to mitigate this vulnerability to ensure the wellbeing of all during the worst of times. The tables in Appendix C summarise many of the resilience options identified by the NZCat team during this project, organised as three critical initiatives, a 'Big 10' of key resilience options for decision makers to consider, and a framework for further policy to build NZ's resilience to nuclear war and other GCRs.

Of note, recent international research has found that the risk from massive volcanic eruption and asteroid/comet impacts is probably larger than was previously thought.[162] Coupled with the nuclear risks we've identified, countries of the world need to model food systems under climate and supply chain stress, as well as the cascading impact of food shortages on trade and supply, run scenarios, and increase the resilience of these systems at community, national, and global level.

10. Co-benefits of catastrophe mitigation

Benefits for management of other risks

Investment in regional and community resilience to protracted catastrophes such as Northern Hemisphere nuclear war will likely enhance local connections and improve resilience to GCRs generally, and other hazards/risks as well.

A range of measures to mitigate the impact of a Northern Hemisphere nuclear war, such as those proposed in this report, would also likely provide resilience across a wider range of global catastrophes, including others that could cause severe trade isolation, such as extreme pandemics, or potential Great Power conflict, such as over Taiwan, or events that impact critical global trade pinch points, such as a massive volcanic eruption near the Luzon Strait. These measures might also reduce the risk posed by more common disaster events, such as earthquakes or extreme weather (Box 25).

Benefits for other national priorities

Many of the measures proposed in this report would, if implemented, also have a positive impact on other national priorities, such as reducing greenhouse gas emissions, developing new industries and expertise, improving food security and population health, mitigating energy price shocks, and increasing national autonomy.

Benefits for humanity

Finally, NZ has special significance in the face of global catastrophe as one of the places often identified as particularly likely to harbour survivors if humanity faces an existential threat. We conclude this report by noting this (see next section). Any cost-benefit analysis of investment in resilience to nuclear war should consider these many co-benefits, as well as potential benefits to the future of humanity.

Box 25

Expected Co-benefits of initiatives for building resilience to nuclear war

Reduced dependence on overseas entities
More NZ autonomy/sovereignty
Reduced greenhouse gas emissions
Improved population health
Development of industries
Improved competitive advantage
Increased energy security
Increased transport security
Reduced costs of local food supply
Inform other countries' resilience plans
Resilience to a wider range of hazards (eg, severe weather events)
Resilience across a range of other global catastrophes
Reduced likelihood of human extinction

Human Civilisation & Existential Risk

Image credit: Hiroshima after the atomic bomb in 1945 (atomicarchive.com)

This report has outlined the vulnerabilities and resilience options for NZ in the face of a Northern Hemisphere nuclear war. Nuclear war is representative of a set of 'abrupt sunlight reducing scenarios' (ASRS) that could devastate agriculture and severely disrupt trade globally. Other ASRS include massive volcanic eruptions and asteroid/comet impacts. However, there are many potential global catastrophes, some which could lead to a collapse of global civilisation, or even human extinction (see Appendix B). Individually uncertain, though collectively plausible, the likelihood of a GCR killing 10% of the world's population by 2100 has been estimated in a 2023 forecasting study to be in the 6–51% range (varying by expert groups).[163]

Many scholars of catastrophe agree that NZ is one of the nations best placed to survive extreme threats to humanity.[164] Therefore, NZ's during-catastrophe functionality may be important not just for its own sake, but for the sake of the overall survival of human civilisation, or even the human species (see the section 'Additional Decision Relevant Information' in the NZCat Nuclear War/Winter Hazard Profile).[165] But as we've detailed above, NZ is by no means certain to continue to flourish in such circumstances.

There are global, humanist, reasons for bolstering NZ's resilience to global catastrophe. In the context of a severe existential threat, a resilient NZ is plausibly the difference between human extinction, and continuation of our species. Achieving true human resilience means understanding the drivers of civilisation collapse and the factors that contribute to preventing it. True human resilience means taking an all-hazards approach to cross-border global catastrophic risks,

understanding the complex interdependencies among human systems, including international food and energy dependencies, and their interdependence with complex adaptive ecological systems.

Island Refuges

Where it is possible and cost-effective to do so, humanity should aim to prevent, respond to, and ensure resilience against GCRs. But there should also be plans for how to recover should things go poorly. Nuclear war is likely to have heterogeneous impacts around the world. Islands in the Southern Hemisphere might be more likely to preserve essential societal and civilisational functions than Northern Hemisphere landmasses in an extreme nuclear winter, because of the thermal moderating influence of the ocean.

Island refuges, such as NZ might provide resilience against GCRs, ensuring that the worst consequences don't spread to affect every location on Earth. Well prepared larger islands like NZ might sustain 'nodes of persisting complexity' thereby ensuring successful continuation of technological civilisation in the aftermath of an extreme global catastrophe, increasing the probability of a global recovery.

Islands such as NZ might look to strengthen political stability, social cohesion, and community resilience. Broad political participation and improving ties between communities, agencies, and organisations appears to have improved social resilience during previous ASRS such as the Late Antique Little Ice Age. Additionally, the insidious creep of mis-/disinformation must be mitigated. There are lessons from the Covid-19 pandemic, the Russian invasion of Ukraine, and other global events, and information hygiene is an important area for ongoing research and resilience building. Ensuring a functioning 'node of complexity' may depend on a pre-catastrophe analysis of the risk of territorial incursion (from state actors, non-state actors, military units, or refugees) and a workable plan for managing this eventuality (see 'Border Issues' above).

A Path Forward

The NZCat project developed information and resources that assess the risk of Northern Hemisphere nuclear war/winter to NZ. The project team engaged as widely as resources permitted and gathered a suite of suggested resilience options. The content in this report is wide-ranging and should help diverse audiences act to reduce global catastrophic risk.

We particularly hope this report can inform discussions on the structure and governance of national risk management processes, sector-by-sector vulnerabilities, and resilience approaches, as well as support communities and local governments to identify likely local vulnerabilities and devise plans to address them.

Our research found that developing anticipatory governance of global catastrophic risk is likely very important, and the 'Risk Governance & Risk Management' section details 'how possibly' this could be done. Governance needs to assure the development of (1) cross-cutting strategies for building resilience to GCRs in anticipation, and (2) plans for how to respond after the fact.

The 'cheat sheets' provide a framework to support resilience discussions and begin to identify who could do what and where, but more ideas are needed. We provide tables in the Appendix below listing 'three critical initiatives', '10 resilience options', and a possible 'Policy Agenda,' that summarise the main findings. Political parties can now address NZ's resilience to global catastrophe. They should be clear where they stand on developing GCR governance and what kind of resilience options they support.

We hope international audiences can use this country-level template to help develop their own nuclear war/winter and global catastrophe hazard profiles and solutions. However, there is still much that is unknown, resilience options to debate, and of course nuclear war is just one of many potential global catastrophes. We hope this is a first step towards a comprehensive approach to global catastrophic risk resilience.

Appendix A: NZCat Project Resource List

The above report is based on a year of productive work among our NZCat team and our engagement with stakeholders and experts in a range of domains and through a range of formats. During this process broad thinking was captured in reports, blogs, interviews, submissions to government, and academic papers. These resources contain greater detail and context and support the findings and resilience options of the present report.

Technical Papers (peer-reviewed) on Global Catastrophe and Risk Management

- Boyd, M., & Wilson, N. (2021). **Anticipatory Governance for Preventing and Mitigating Catastrophic and Existential Risks**. *Policy Quarterly, 17*(4), 20–31. doi:10.26686/pq.v17i4.7313
- Boyd, M., & Wilson, N. (2022). **Island refuges for surviving nuclear winter and other abrupt sunlight-reducing catastrophes**. *Risk Analysis*. doi:10.1111/risa.14072
- Wilson, N., Prickett, M., & Boyd, M. (2023). **Food security during nuclear winter: a preliminary agricultural sector analysis for Aotearoa NZ**. *N Z Med J, 136*(1574).
- Wilson, N., Payne, B., & Boyd, M. (2023). **Mathematical optimization of frost resistant crop production to ensure food supply during a nuclear winter catastrophe**. *Scientific Reports, 13*(1), 8254. doi:10.1038/s41598-023-35354-7
- Boyd M, Ragnarsson S, Terry S, Payne B, Wilson N (2023). **Mitigating Imported Fuel Dependency in Agricultural Production: Case study of an island nation's vulnerability to global catastrophic risks**, 17 August, PREPRINT (Version 2) available at Research Square [https://doi.org/10.21203/rs.3.rs-3273609/v2]
- Wilson, N., Valler, V., Cassidy, M., Boyd, M., Mani, L., & Brönnimann, S. (2023). **Impact of the Tambora volcanic eruption of 1815 on islands and relevance to future sunlight-blocking catastrophes**. *Scientific Reports, 13*(1), 3649. doi:10.1038/s41598-023-30729-2

NZCat Research Reports

- **Hazard Profile for Nuclear War/Winter**: 'Aotearoa NZ Catastrophe Resilience Project (NZCat): Nuclear War/Winter Hazard Profile' [link]:
- **Multidisciplinary Nuclear War/Winter Workshop (Feb 2023):** 'Workshop on Nuclear War/Winter & NZ: Wellbeing of millions and $1 trillion plus at risk, strategic resilience must become bread & butter NZ policy' [link]
- **Qualitative Survey of Experts**: 'NZ and Global Catastrophe: A picture of vulnerability, a pathway to improved resilience: Analysis Report of Interview Data from the Aotearoa NZ Catastrophe Resilience Project (NZCat)' [link]
- **NZCat Expert Interview Study Report**: 'NZ and Global Catastrophe: A picture of vulnerability, a pathway to improved resilience: Analysis Report of Interview Data from the Aotearoa NZ Catastrophe Resilience Project (NZCat)' [link]

Blogs

The following blogs were published by the NZCat Project Team during Nov 2022–Nov 2023:

- NZ's National Security Draft Long-term Insights Briefing (LTIB): Excellent Progress but Scope for Improvement [link]
- Development of a National Security Strategy (plus NEMA) is one part of a National Risk Approach [Link]

- Nuclear War and NZ: Impact and Mitigation Approaches [Link]
- US takes action to avert human existential catastrophe: The Global Catastrophic Risk Management Act (2022) [Link]
- Workshop on Nuclear War/Winter & NZ: Wellbeing of millions and $1 trillion plus at risk, strategic resilience must become bread & butter NZ policy [Link]
- A Historical Volcanic Winter & Future Sunlight-Blocking Catastrophes: New Study [Link]
- Revolutionising National Risk Assessment (NRA): improved methods and stakeholder engagement to tackle global catastrophe and existential risks [Link]
- Yes, NZ needs a systematic National Risk Assessment; but we must not repeat others' mistakes [Link]
- Risk and Resilience in the Face of Global Catastrophe: A Closer Look at NZ's Food Security [Link]
- Food for thought: Frost resistant crops to hedge against the impacts of nuclear winter [Link]
- Surveying Survival: What Experts Think About NZ's Resilience to Nuclear Winter [Link]
- Rethinking Risk: Towards a More Comprehensive Security Strategy for NZ [Link]
- Where do NZ political parties stand on long-term and catastrophic risk? Survey answer: nowhere [Link]
- Large volcanic eruptions originating elsewhere threaten NZ and other remote nations [Link]
- Expert Views on Aotearoa NZ's Vulnerability and Resilience to Nuclear War and other Global Catastrophes [Link]
- Embracing downward counterfactual analysis to navigate future cyclones [Link]
- The need for long-term thinking – Especially for preventing catastrophic risks [Link]

Submissions to Government

- NZ Economic Resilience: Submission to the Productivity Commission – Focus on Global Catastrophic Risks: https://www.productivity.govt.nz/assets/Submission-Documents/resilience/Sub-003-Adapt-Research-Ltd-submission.pdf
- Critical Infrastructure Resilience Regulation: Submission to DPMC: https://adaptresearch.files.wordpress.com/2023/07/230731-nzcat-adapt-research-submission-to-dpmc-critical-infrastructure-resilience.pdf

Other Media

- Kōrero on Catastrophe - **NZCat Webinar and Panel Discussion** (25 Oct 2023): https://adaptresearchwriting.com/2023/10/29/korero-on-catastrophe-nzcat-webinar-panel-discussion-on-resilience-to-nuclear-war-and-other-global-risks/
- Peter Griffin interviews NZCat lead author Dr Matt Boyd on the Business of Tech podcast (21 Sept 2023): https://businessdesk.co.nz/article/podcasts/business-of-tech-podcast-from-runaway-ai-to-nuclear-war
- Do we really need to prepare for nuclear war? (13 May 2022, Radio NZ interview with NZCat team members Dr Matt Boyd and Prof Nick Wilson): https://www.rnz.co.nz/programmes/the-detail/story/2018841654/do-we-really-need-to-prepare-for-nuclear-war
- NZCat lead author Dr Matt Boyd talks about island refuges at the Cambridge Centre for Study of Existential Risk (21 Oct 2022): https://adaptresearchwriting.com/2022/10/25/islands-and-global-catastrophic-risks-a-seminar-at-the-cambridge-centre-for-the-study-of-existential-risk/
- Ben Reid interviews NZCat lead author Dr Matt Boyd on the Memia podcast (June 6 2022): https://memia.substack.com/p/memia-podcast-3-matt-boyd-on-global#details

Appendix B: List of risks to NZ

Table A1: List of nationally significant risks/threats to NZ
(Compiled from: DPMC Nationally Significant Risks website, NZ National Security Strategy 2023, Contents page of Bostrom/Cirkovic (2008) 'Global Catastrophic Risks', List in Wilson/Boyd (2023) National Risk Registers paper, UK National Risk Register (2023) – subitems excluded if heading item already included, ChatGPT: list the global catastrophic risks and x-risks).

Category	**Risks** * = Potential global catastrophic risk (GCR) *italic* = does not appear to be publicly addressed in NZ
DPMC Nationally Significant Risks (lead agency indicated)	**NATURAL/ENVIRONMENTAL** Drought (MPI) Earthquake (NEMA) Coastal hazards (NEMA, MfE) Floods (NEMA, MfE) Severe Weather (NEMA, MfE) **Space Weather (TBC)*[1] Tsunami (NEMA) *Volcanic activity (NEMA)[2] Wildfire (FENZ) Biodiversity loss (DoC) Ecosystem disruption (soil) (MfE) Resource depletion (marine) (MPI) **BIOLOGICAL & HUMAN HEALTH** Pests & diseases (MPI) *Communicable diseases (MoH)[3] Vector-borne diseases (MoH) Food safety incident (MPI) *Global navigation system disruption (TBC)* *Critical infrastructure failure (water, energy, transport, ICT) (DIA, MBIE, MoT)[4] Fire & explosions (FENZ) Hazardous substances emergency (FENZ) Major oil spill (MaritimeNZ) Radiological incident (MoH) Major transport incident (MoT) **ECONOMIC CRISES** Commodity/energy price shock (MBIE)

[1] Effects of solar activity on the electromagnetic condition in the near space around the Earth. This can cause severe geomagnetic disturbance that **could negatively impact information and communications technology (ICT), global navigation satellite system (GNSS), and other critical infrastructure, including national (electricity) grids**, navigation/operation of aircraft, and the safety of passengers and crew.
[2] Volcanic eruption or sustained levels of volcanic unrest, which may or may not be a precursor to an eruption. Volcanic **hazards include ash fall, lava flows, pyroclastic flows (superheated ash and gases), ballistic ejecta, lahars (ash and mudflows) and toxic gas emissions**
[3] Diseases that spread from one person to another or from an animal to a person. Communicable disease events may lead to localised outbreaks or result in more **widespread epidemics or pandemics**
[4] Significant loss of nationally significant services due to the disruption or loss of infrastructure, across four core sectors, including **water, energy, transport, and information and communications technology** infrastructure sectors (not clear if this includes total failure, eg, no transactions, no diesel).

	*Major trade disruption (MFAT, MPI)[5] Financial crisis (NZ Treasury) **MALICIOUS THREATS** *Armed conflict (NZDF, MoD)[6] Weapons proliferation (MFAT) Civil unrest (NZ Police) Corruption (SFO) Foreign interference & espionage (NZSIS, DPMC) Pacific regional instability or emergency (MFAT, MoD) Mass arrivals (MBIE – Immigration NZ) Major cyber incident (GCSB, DPMC) Maritime territorial incursion (NZDF, MoD) Terrorism (NZ Police, NZSIS, DPMC) Transnational organised crime (NZ Police, Customs) Border incursion (NZ Customs)
National Security Risks (covered by 2023 National Security Strategy)	Strategic competition & rules based system Emerging, critical, sensitive technologies Disinformation Foreign interference & espionage Terrorism & violent extremism Transnational organised crime Economic security Pacific resilience & security Maritime security Border security Cyber security Space security
GCRs (that could be existential risks)	**NATURAL/ENVIRONMENTAL** Supervolcano eruption (NZ or *elsewhere*) *Asteroid/comet impact* **TECHNOLOGICAL/HUMAN** *Nuclear war*[7] Artificial general intelligence[8] *Bioengineered pandemic*[9] Climate change (Nanotechnology) **OTHER**

[5] **Many natural, economic, and political factors could cause this**, including market access risks, biosecurity threats (such as an outbreak of foot and mouth disease), a major shock to multiple countries such as a pandemic or global financial crisis, and risks to the safe transport of goods to and from NZ (unclear if this includes a no trade, no oil scenario)

[6] Armed conflicts, even when principally conducted in specific geographic areas, can have much wider impacts. These can include disruptions to global supply chains, international relationships, multilateral organisations, and the international information environment. **This risk focuses on armed conflicts the NZ Government decides to commit national capabilities to** protect, preserve and promote our interests to, particularly including the NZ Defence Force

[7] Not covered in Nationally Significant Risks or National Security Strategy ('Armed conflict' focuses on those in which NZ participates)

[8] Probably comes under 'emerging technologies'

[9] Not specifically covered in Nationally Significant Risks or National Security Strategy

	Interactions or cascades of the above risks Unknown risks (eg, technological, extra-terrestrial, physics mishap etc)
GCRs (that are not likely to be existential risks)	**NATURAL/ENVIRONMENTAL** Natural pandemic Solar flares/geomagnetic storms *Cosmological risks (gamma ray bursts, supernova)* *Global food shock* **TECHNOLOGICAL/HUMAN** *Great Power war* *Global systems collapse* (eg, total loss of telecommunications cables etc) *CBRN attacks in the world* Advanced technology (other than AGI, bio, nano) Geoengineering *Resource depletion* *Ecological collapse* *Totalitarianism* Humanitarian crisis that triggers collapse **OTHER** Interactions or cascades of the above risks Unknown risks

Appendix C: NZ Nuclear War/Winter Resilience Options Overview

Table A2

NZCat: Three Critical Priorities	
1. **Immediately undertake a systematic & comprehensive National Risk Assessment** (that explicitly includes global catastrophic risks)	WHAT: • A systematic analysis of the likelihood and consequences of the full range of nationally significant risks, including cross-border risks, such as nuclear war (eg, NZCat's nuclear war/winter Hazard Profile), and other GCRs WHY: • An agreed set of risks provides reference probabilities and expected consequence settings to inform systematic cost-benefit analysis and prioritisation of interventions • Collective analysis of national risks identifies common consequences across low probability risks, which collectively might be significant • A publicly facing National Risk Register empowers businesses and communities to take resilience action and signals NZ's understanding of risk to cooperative partners
2. **Immediately develop an updated National Fuel Plan** (that quantifies the volume needed by critical sectors and how to supply it)	WHAT: • An updated National Fuel Plan that includes assessment of how much fuel critical processes such as agricultural production and transport of food require in a protracted (months/years) zero-trade situation, and options for supply, including eg, biofuel production for life-supporting industry. WHY: • Without liquid fuel, present-day industry would grind to a halt in weeks • It is important to know the rate at which fuel may be consumed, across months or years of serious disruption to petroleum trade, to ensure life-supporting activities such as growing and transporting food can continue • Understanding quantities will inform important decisions such as how much biofuel feedstock to cultivate and how much biodiesel production is needed in a global catastrophe. • The implications of fuel insecurity flow beyond NZ's borders, given the potential dependence of millions of people on food exported from NZ, especially in a global catastrophe.
3. **Initiate a government-supported, long-term, nationwide narrative of cooperation and programme of community resilience-building** (with global catastrophe the explicit target).	WHAT: • There should be a national effort to identify, develop and implement community and regional plans and projects that address the consequences identified in the systematic National Risk Assessment (see #1 above). This ought to include increasing community connectivity (among organisations and individuals), resilience-building, and development of self-sufficiency (eg, local food & energy production and distribution, local communication networks, and local expertise) • This programme of community resilience building should be framed and supported by a narrative of cooperation and shared responsibility, underpinned by clear and comprehensive risk information. WHY: • In a global catastrophe such as Northern Hemisphere war/winter, NZ could be severely impacted as a whole. Regions and communities suffering consequences may not be able to count on external assistance. Communication might be difficult.

	• Communities that have high social capital, and a cooperative mindset do well in catastrophes.

Table A3

NZCat 'Big 10' Resilience Options	
1. **Risk Management 1**: Legislate the inclusion of GCRs such as nuclear war in the DPMC list of 'Nationally Significant Risks'	The DPMC list of nationally significant risks omits high-impact threats and hazards such as nuclear war (and other GCRs and their consequences). Yet, these risks plausibly contain most of the expected harm, and may be unbearable should they strike. The US recognises this with its 2022 Global Catastrophic Risk Management Act, NZ could replicate this legislation to ensure ongoing attention to the greatest risks.
2. **Risk Management 2**: Develop a set of 'Resilience Strategies' for the major sectors underpinning NZ society & economy: - Energy - Transport - Food/Agriculture - ICT/digital	Listing the GCRs (as above) is not enough. Risk assessments must be connected to a plan for building capabilities. These plans (covering core sectors) need to explicitly contemplate scenarios of abrupt global catastrophe such as nuclear war. In some cases, there are already calls for (eg, a National Food Security Strategy) or plans for (eg, an Energy Security Strategy) similar strategies, which could be expanded to explicitly consider and plan for GCRs.
3. **Risk Management 3:** Improve long-term governance of global catastrophic risk by establishing an independent Parliamentary Commissioner or Chief Risk Officer to advise a bipartisan Parliamentary Committee	Without independent analysis and advice there is a risk that catastrophe management becomes politicised or undermined by short-term policy agendas. Establishing high-level risk governance, accountability, and bipartisanism will help sustain the needed focus on management of global catastrophe, such as nuclear war.
4. **Food:** Develop a National Food Security Strategy and diversify food produced, decreasing dependence on imported industrial agricultural inputs	NZ has the potential to produce vast quantities of food, but this potential currently depends on imported inputs, and lacks diversity. Increasing diversity (of grains, fruit, vegetables) and practices based on local resource inputs, can ensure an easy pivot to less resource intensive cropping per food calorie (eg, wheat/potatoes, rather than dairy milk) in case of global catastrophe.
5. **Fuel:** Increase energy efficiency and reduce demand, while developing biodiesel refining capacity (and feedstock) sufficient to sustain minimum agriculture & food transport in a global catastrophe	In a global catastrophe liquid fuel imports could end, perhaps in the context of a downturn in renewable energy production due to altered climate in nuclear winter, and difficulties maintaining critical centralised energy infrastructure. The most pressing problem would be a lack of diesel for transport and agriculture. Until there is widespread electrification, some locally produced alternative liquid biofuel is needed.
6. **Transport:** Invest in a mix of rail and coastal shipping assets (including resilient interisland transport)	To increase capacity and provide transport options in case of severe disruption to road trucking (see 'Fuel'). Ideally, there is investment in accelerating electrification of road, rail, coastal shipping, and interisland air travel, and assets to facilitate regional international trade in the absence of global shipping.
7**. ICT/digital:** Develop a National Digital/Govt Communications Continuity Plan	There is risk of failure of overseas digital infrastructure providers, severance of connectivity to global internet, and the challenge of NZ ICT/digital infrastructure maintenance in the absence of global trade. The result is the inability to share crisis information or transact locally in NZ. This risk could be reduced through development of a Digital

	Communications Continuity Plan, investment in local NZ digital infrastructure, including cloud services, expertise, and through scenario testing of loss of global connectivity.
8. **Economy:** Develop a Reserve Bank Plan for an extended scenario of no digital payments nationwide	Severe disruption to trade and ICT/digital services (as above) could leave NZ unable to complete digital transactions, with need to shift to a more cash-based society. The government and reserve bank should develop and share plans for this scenario and an orderly closure of financial institutions.
9. **Trade:** Diversify export markets (eg, develop Southern Link trade route & infrastructure) and diversify domestic products to ensure sought after offerings in a global catastrophe	NZ is critically threatened by trade isolation. A key hedge would be to ensure before-the-fact trade options and supporting infrastructure exist to facilitate trade with a wide range of regions, to decrease dependence on Northern Hemisphere trade, and to identify alternatives to trade through vulnerable global pinch points.
10. **International Cooperation**: work with Australia (with shared understanding of National Risk Assessments) to ensure resilient regional trade and a shared mix of critical commodities in case of global catastrophe	No one country can mitigate global catastrophe alone, so a cooperative approach is needed. Cooperation with Australia seems potentially critical and collaborative risk assessment, plans to facilitate trade, and a cooperative approach to supplying necessities could help alleviate issues across food, transport, energy, and ICT/digital disruption.

Table A4

NZCat: Global Catastrophe Policy Agenda (in addition to the above)			
	Short term	**Medium term**	**Longer term**
Governance	• Ensure DMPC consultation into critical national infrastructure regulation identifies ICT/digital tech, such as cloud services, as critical national infrastructure, and expand analysis to identify needed 'resilience' infrastructure and critical continuity plans • Revise Emergency Management Bill 2023 to explicitly address GCRs	• Appoint a National Chief Risk Officer • Appoint a National Risk Assessment Committee comprised of expert public sector, private sector, academic and community representatives • Appoint a National Chief Technology Advisor (and Technology Investment Agency)	• Institutionalise a Parliamentary Commissioner for Extreme Risks & Bipartisan Risks Committee
Research needs	• Model extreme global food shock and the impact on NZ's trade and economy • Detailed all-hazards vulnerability assessment of food calorie production (including nuclear/volcanic winter,	• Initiate a National Science Mission to coordinate research of GCRs and NZ • Optimisation analysis for agriculture/food distribution under zero fuel scenarios • Model NZ energy production under	• Wind assist technology for coastal shipping • Research NZ potential to develop resilient foods (to maximise population that can be supported)

	no-trade scenarios, and pre-industrial farming) • Model demand reduction for electricity/energy to identify optimal approach to winding back energy use while providing basic needs	nuclear/volcanic winter conditions • Identify the possibilities for substantial urban agriculture, and quantify potential for local food supply and land use options	
Government Analysis	• Quantify biofuel requirements for each transport sector (eg, coastal & interisland shipping, non-electric rail, road trucking) • Audit capacity for trans-Tasman trade independent of global shipping • Audit strategic significance of imported commodities to NZ's ability to supply basic needs. • Use scenarios (including nuclear/war & GCRs) to identify the best mix of energy supply • Conduct walk through of extended scenario where digital transactions are impossible nationwide	• Collaborate with Australian risk management system to reduce analytic duplication of GCRs and identify collaborative resilience opportunities • Systematically perform cost-effectiveness analyses (that include the likelihood and consequences of GCRs) across all major proposed resilience initiatives, and use results to prioritise resources • Develop a programme of regular cross-sector/inter-agency GCR scenario walk throughs • Develop a programme of regular audit of transport, energy, ICT/digital infrastructure, maintenance, and spare parts	
Synergy with existing Programmes	• Include GCR scenarios in national calls for a Food Security Strategy • Include a GCR lens in food resilience planning initiatives • Intensify recycling programmes for imported commodities such as lubricating oils	• Ensure MBIE's NZ Energy Strategy (2024) indicates how to aggressively reduce dependence on imported fuel and incentivise distributed electricity generation • Community education about importance of 100% renewable energy	• National Adaptation Plan and other climate responses to incentivise reduction in monocropping, increased local dietary sourcing flexibility

		• Expand MoT Freight & Supply Chain Strategy to include a National Transport Resilience Strategy under a GCR lens • Immigration and skills retention settings to ensure resilience expertise (energy, ICT/Comms, transport, food, etc) remains onshore	
Infrastructure Investments	• Strategic stockpiles of critical commodities • Develop and curate datasets that inform the risk management of nuclear war and other GCRs • Conduct a risk analysis for possible stranded assets • Policy settings and incentives that encourage investment in people-centred, accessible urban environments	• Invest in shipping infrastructure for minimum level of trans-Tasman trade (in isolation scenario) • Decentralised liquid fuel storage (to overcome transport bottlenecks) • Develop NZ biofuel refining capability and feedstock • Invest in diverse and local energy sources & electrification of infrastructure • Invest in ICT/Comms resilience, including standalone local cloud/digital technology	• Develop regional (Australia/NZ) production capacity for agricultural inputs (seed, fertiliser, agrichemicals) • Data centres to support independent local NZ cloud services and internet located in both North and South Island • Develop offline physical data repositories of critical knowledge

Appendix D: Glossary (terms and acronyms)

All-hazards approach: A preparedness strategy that plans for a wide range of potential emergencies or disasters, regardless of their cause, by developing processes and capabilities applicable to any type of incident.

Artificial intelligence (AI): The simulation of human intelligence processes by machines, especially computer systems, enabling them to perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, perception, and language understanding.

Biological threats: Risks posed by harmful biological substances or organisms, such as viruses, bacteria, other pathogens, or biological toxins, whether naturally occurring or manmade, that can affect human health, agriculture, or the environment, potentially causing disease, death, or ecological disruption.

Capital: The diverse assets or resources that can be categorised into various forms, including natural capital (eg, ecosystems and resources), human capital (eg, knowledge and skills of individuals), physical capital (eg, infrastructure and equipment), and social capital (eg, social networks and relationships). These assets contribute to the overall wealth, well-being, and capabilities of individuals, organisations, or societies.

Catastrophe: A severe and often sudden event that causes great damage or loss.

Civilisation collapse: The rapid and significant loss of an established human society's cultural identity, structure, and function, often marked by a decline in political, economic, and social complexity.

Climate change: A long-term alteration in Earth's climate patterns, commonly evidenced by temperature fluctuations, changes in precipitation, and shifting weather events, largely attributed to human activities such as burning fossil fuels.

Complex risk: The multifaceted and interconnected nature of certain risks, where multiple factors and systems interact in unpredictable ways, making the risk challenging to understand, predict, and manage.

De-escalation: The reduction of intensity or severity in a conflict or potentially volatile situation, often through communication, negotiation, or other means to prevent further hostilities or violence.

Department of the Prime Minister and Cabinet (DPMC): A central government agency that provides support and advice to the Governor-General, the Prime Minister, and members of the Cabinet of New Zealand.

Electromagnetic pulse (EMP): The burst of electromagnetic radiation that results from certain types of high energy explosions, such as a nuclear explosion, or from a suddenly fluctuating magnetic field. An EMP can disrupt or damage electronic equipment and power lines due to the rapid change of electrical and magnetic fields in the environment. The effects can range from minor interference with signal transmission to complete destruction of electronic circuits and systems.

Emergency Management Bill (2023): Proposed legislation intended to update and improve the legal framework for emergency management in NZ, focusing on the response to and recovery from emergencies, enhancing resilience, and ensuring a coordinated effort among various agencies.

Global catastrophic risks (GCR): Events or scenarios that have the potential to cause severe and widespread harm on a global scale, affecting human civilisation or even threatening its existence (existential or x-risks). GCR typically encompass a broad range of threats, such as pandemics, nuclear warfare, asteroid impacts, and runaway climate change, among others, that could lead to catastrophic consequences for humanity and the planet.

Globalisation: The process by which businesses, cultures, and populations become interconnected and interdependent on a global scale, driven by trade, investment, information technology, and the movement of people.

Global shock: A widespread, unexpected event that causes significant disruption or changes across multiple countries and economies simultaneously, often leading to far-reaching social, economic, or political consequences.

Hectoring: A form of behaviour characterised by bullying language often used to intimidate and apply pressure.

Inter-societal: Pertains to the interactions (eg, conflicts) or relationships between different societies or social groups.

Intra-societal: Activities, processes, or interactions (eg, conflicts) that occur within a single society or social group.

National risk assessments (NRA): Comprehensive evaluations conducted by governments to identify and analyze potential threats, hazards, and vulnerabilities, that could pose significant risks to a country's citizens, security, economy, infrastructure, or other critical aspects. These assessments aim to provide a systematic understanding of various risks, their likelihood, potential consequences, and the measures needed to mitigate or manage them effectively. They serve as a foundation for policymaking, resource allocation, and risk reduction strategies at the national level.

National risk register (NRR): A document published by a government communicating the likelihood and potential impact of various risks (such as natural disasters, pandemics, or terrorist attacks) on a national scale, used to inform planning, preparedness, and response strategies.

National Security Strategy: The framework implemented by DPMC that outlines NZ's approach to identifying, assessing, and addressing threats and challenges to national security, encompassing policies and actions to protect its citizens, assets, and interests.

National Emergency Management Agency (NEMA): The government entity responsible for leading NZ's emergency management, ensuring readiness for, response to, and recovery from emergencies and disasters.

NATO: The North Atlantic Treaty Organization is an intergovernmental military alliance between 30 North American and European countries established to provide mutual defence in response to an attack by any external party.

New Zealand Infrastructure Commission, Te Waihanga: An independent government agency responsible for providing strategic advice, coordination, and leadership in the planning, development, and management of infrastructure in New Zealand.

New Zealand Lifelines Council: A government-appointed organisation responsible for coordinating and ensuring the resilience of critical infrastructure systems, often referred to as 'lifelines,' in New Zealand. These lifelines include key sectors such as transportation, energy, water supply, and telecommunications. The council's primary role is to enhance the preparedness, response, and recovery capabilities of these lifeline systems during emergencies, natural disasters, and other disruptive events to help maintain essential services and protect public safety.

Nuclear war: An event in which a state attacks another state with nuclear weapons. This definition excludes nuclear terrorism and other attacks by nonstate actors, unauthorised detonations (which are made against the intentions of state authorities), and accidental nuclear detonations (which no one authorises), unless these events cause interstate nuclear war.

Nuclear winter: A climate condition that could result from widespread firestorms following a large-scale nuclear war, leading to significant cooling, and darkening of the Earth's surface, potentially for years, due to smoke and soot in the atmosphere blocking sunlight.

Red-teaming: rigorously challenging plans, policies, systems and assumptions by adopting an adversarial approach.

Resilience: The capacity to withstand, adapt to, and recover from disruptions or adversity; it denotes toughness and the ability to bounce back from adverse conditions or challenges**.**

Resilience framework: A structured approach that outlines methods and strategies to enhance the ability of a system, organisation, or community to withstand, adapt to, and recover from disruptions or adversity.

Risk cascades: A sequence of worsening consequences where one event triggers a series of subsequent events or failures, often escalating a situation beyond its initial scope and causing amplified negative effects.

Socio-technological: The interactive and interdependent relationship between society and technology, encompassing how technological use and advancements affect social systems and how societal context influences technology.

Superforecasters: Individuals who have demonstrated exceptional skill in making accurate and precise predictions about future events, often in the context of geopolitical, economic, or other complex and uncertain situations. They are known for their ability to consistently outperform the general population and even expert analysts when it comes to forecasting future outcomes, thanks to their use of rigorous analytical techniques, probabilistic thinking, and a willingness to continuously update their predictions based on new information.

Systemic risk: The potential for a disruption within a system or entire sector, such as the financial market or global economy, to cause widespread instability or collapse due to the interdependencies within the system.

US Catastrophic Risk Management Act (2022): An Act aimed at establishing guidelines and measures to better manage and mitigate the impact of catastrophic events on a national level in the United States, focusing on risk assessment and the supply of basic needs in a catastrophe situation.

Appendix E: Endnotes

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