Governance Under Fallout: Anticipating and Navigating the 2nd Order Impacts of a Nuclear Strike

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Executive Summary

This report addresses the 2nd order impacts of a nuclear strike, being systemic and cascading consequences that unfold long after the initial detonation and may ultimately determine the resilience or collapse of complex societies. Drawing on structured horizon scanning with eight cross-disciplinary experts, 21 potential issues were distilled to a shortlist of twelve and deliberated in strategic foresight workshops. This process revealed a set of critical challenges and potential solutions that go beyond the immediate effects of nuclear conflict.

The convening authors and specialist co-authors want to note that any nuclear exchange would be a horrific tragedy, and if even ‘moderate’ in scale liable to lead to potentially extinction level outcomes. None of these resilience measures - some of which are also useful for consideration due to their formulation for extreme societal breakdowns in general - would reasonably address the sheer destruction of an exchange.

A moratorium on use, and ultimate disarmament remain noble aims that should be pursued. As such this exercise should not be taken as outlining measured efforts at survival, but as last ditch safeguards to a terrible potentiality. That said, the terribleness of such outcomes does not necessarily make studying them an infohazard; society will be completely exposed to such extreme hazards if there is no degree of societal and technical resilience thinking beforehand. May these insights never need to be used, and if so, in less cataclysmic but structurally severe breakdown scenarios.

Our analysis shows that traditional nuclear preparedness remains too narrowly focused on immediate destruction while neglecting the fragility of interlinked systems such as food production, transport, health care, governance and social cohesion. The report highlights that civilisational risks—systemic disruptions falling short of extinction thresholds—are central to understanding nuclear conflict’s long term effects.

Key 2nd order issues and indicative solutions identified include:

- **Weaknesses in humanitarian logistics and supply chains**, where local stockpiles and alternative foods can help ensure continuity.

- **Vulnerability of transport networks**, requiring more diversified domestic routes and decentralised hubs.

- **Risks to food systems and health**, addressed through national self sufficiency, resilient seed systems, seaweed based nutrition and UV tolerant crops.

- **Institutional fragility and social instability**, countered by inclusive civil defence, resilient knowledge commons and strengthened local social infrastructure.

- **Emerging technological and geopolitical shifts**, including AI enabled command and control and polar access, which demand built in safeguards and adaptive capability.

Policy recommendations for national security and resilience decision makers:

- **Whole-of-government continuity planning**: Every major department should develop and regularly stress test continuity plans for scenarios extending beyond immediate blast damage, including prolonged loss of critical imports, cyber-physical disruptions and mass displacement. Plans should map dependencies across energy, finance, food and information systems, and include clear triggers for activating emergency powers and for de-escalating them to preserve democratic legitimacy.

- **Food and supply security at scale**: Establish diversified, regionally distributed reserves of essential goods and medical supplies, paired with transparent rotation policies to avoid spoilage. Invest in controlled environment agriculture, agroecological regenerative practices and resilient seed systems to reduce vulnerability to nuclear winter conditions. Create standing international mechanisms for emergency food trade that explicitly prioritise the global majority most at risk.

- **Health and social system durability**: Build long duration surge capacity for radiological exposure, infectious disease and chronic trauma. Expand mental health and community support programmes to sustain social cohesion and reduce the appeal of extremist movements in post-strike conditions. Incorporate gender sensitive recovery frameworks to ensure equitable access to services.

- **Strengthened global governance and cooperation**: Reinforce and update nuclear arms control and non-proliferation agreements, create standing multilateral platforms for 2nd order impact planning and develop international certification standards for food systems infrastructure and recovery. Use these platforms to facilitate equitable burden sharing with low and middle income

countries.

- **Strategic foresight and participatory governance**: Embed foresight units within national security agencies and require cross-sector scenario exercises involving local governments, civil society and critical infrastructure operators. Integrate Indigenous and local knowledge to accelerate recovery capacity and ensure intergenerational fairness metrics are built into resilience planning. Establish open access data infrastructures to support coordinated decision making in real time.

- **Decentralised transport and logistics networks**: Incentivise diversification of domestic transport routes, support polar class vessels for high latitude access and maintain flexible procurement chains for humanitarian logistics. Encourage local manufacturing of essential items and pre-positioned stockpiles to avoid single point failures.

Together, these measures move policy from reactive emergency response to proactive systems level resilience building. By anticipating and mitigating cascading harms, decision makers can better safeguard institutional legitimacy, social stability and the continuity of societies after a nuclear strike. All these resilience measures are also useful in other disruption scenarios, and do not exclusively pertain to the 2nd order impacts of a nuclear strike.

Abstract

A nuclear strike represents one of the most severe global catastrophic risks, yet much of the existing literature and policy planning has focused on immediate, first-order impacts such as blast damage and acute mortality. Less attention has been paid to the cascading, 2nd order impacts that may ultimately shape long-term civilisational resilience. To address this gap, we present a horizon scan of systemic risks arising from nuclear conflict.

8 experts across diverse disciplines submitted 21 issues, which were refined through structured elicitation and scoring into a shortlist of 12, and subsequently deliberated through Horizon Summit workshops, which applied strategic foresight methodologies to diagnose and prognosticate complex issues and their solutions. Issues included institutional breakdown of nuclear arms controls, long-term supply chain disruptions and collapses in agricultural systems leading to long-term food insecurity. This unique methodology highlights the need to move beyond narrow assessments of immediate

harm toward a broader understanding of long-term effects, and solutions to, the 2nd order impacts of a nuclear strike.

Introduction

We are living in an era of proliferating systemic risks, marked not only by their increasing frequency but also by their complex interconnections and cascading effects (Mark et al., 2024).

Among the most profound of these risks is nuclear conflict. While much scholarly and policy attention has been devoted to the immediate, first-order impacts of a nuclear strike (blast damage, thermal radiation, and acute mortality), the 2nd order impacts demand equal if not greater scrutiny (Apikyan & Diamond, 2015). These indirect and cascading consequences, including disruptions to food systems, long-term public health crises, mass displacement, geopolitical destabilisation may ultimately prove more determinative of civilisational resilience than the initial event itself (Juan et al., 2021; Xia et al., 2022; Blouin et al., 2024).

Global catastrophic risk (GCR) is typically defined as the “probability of a loss of 25% of the global population and the severe disruption of global critical systems within a given timeframe” (Kemp et al., 2022). Yet nuclear conflict also highlights the importance of civilisational risks: systemic disruptions that may fall short of extinction thresholds but nonetheless undermine the viability of complex societies. 2nd order impacts are central to this understanding, as they illuminate how initial shocks cascade through interdependent systems, producing path dependencies that shape long-term trajectories.

Issues like climate change and pandemics illustrate why global catastrophic risks and civilisational risks cannot be adequately understood in isolation. Complex causal pathways, feedback effects, and cross-domain interactions require integrative approaches that combine foresight with participatory governance (Cremer & Kemp, 2021; Undheim, 2023).

In the case of nuclear conflict, focusing exclusively on immediate destruction can obscure an understanding of the longer-term governance challenges that follow. Solutions must therefore move beyond short-term emergency response to encompass the design of institutional, ecological, and economic systems capable of absorbing shocks, mitigating cascading harms, and supporting recovery. Yet such forward-looking governance is hindered by disciplinary silos, overreliance on historical analogies and entrenched inequities in information, resources, and decision-making power (Yang & Sandberg, 2023). The global majority—those most vulnerable to long-term nuclear

effects—remains constrained in its ability to shape protective policies, even though it often bears the severest burdens when disasters strike (Borrie, 2014).

Building on literature in anticipatory governance and civilisational risk studies (Kemp et al., 2022; Cremer & Kemp, 2021; Avin et al., 2018; Miller & Poli, 2021), this paper explores the systemic consequences of nuclear conflict beyond its immediate effects, and examines pathways toward governance solutions that can safeguard intergenerational fairness, institutional legitimacy, and civilisational continuity.

Methodology

This study employed a structured horizon scanning process, followed by a culminating Horizon Summit (see Figure 1 and 2), to identify and deliberate on priority risks, and their solutions, of the 2nd order impacts of a nuclear strike. The methodology comprised four main stages:

1. Participant Recruitment

8 expert participants were recruited, representing diverse disciplinary backgrounds across key fields relevant to global catastrophic and civilisational risk. Recruitment was informed by leading publications, academic departments and major conferences.

These experts were:

- **Daniel Aldrich** - Director, Resilience Studies Program and Professor, Political Science and Public Policy, Northeastern University
- **Sarah Schiffling** - Assistant Professor in Supply Chain Management and Social Responsibility, Hanken School of Economics
- **Kat Morgan -** Associate, The Rockefeller Foundation
- **Jana Baldus -** Policy Fellow, European Leadership Network
- **Adis Dzebo** - Senior Research Fellow, Stockholm Environment Institute
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- **Joshua Coupe** - Research Scientist, University of Colorado Boulder
- **Sara Talebian** - Senior Research Fellow, Stockholm Environment Institute

Diversity in expertise and experience was prioritised, recognising its importance in ensuring the robustness of collective intelligence (Yang & Sandberg, 2023).

The nuanced and specialised nature of this topic area made recruitment of experts difficult. While we intended to recruit a larger group of experts, only a moderate number of experts felt competent and willing to contribute to this study, meaning we had a smaller sample of experts than we desired.

2. Elicitation of Issues

Participants were asked to submit potential tipping points and systemic issues that manifest as 2nd order impacts of a nuclear strike, and their associated solutions. These were across social, environmental, economic and political domains. Issues were especially prioritised when they had a long-term chronic impact, and therefore crucial in nuclear security discourse.

All participants provided full academic references for their issues and solutions, providing a diverse literature base for analysis.

To ensure conceptual clarity, participants were provided with key definitions of relevant terms (see Table 1).

Table 1 - Key definitions provided to the experts

Civilisational Risk	*Civilisational risk broadly refers to a spectrum of risks, which represent the potential for a severe decline in global living standards, a permanent limitation to humanity's future potential, loss of 25% of the global population with disruption of critical systems, and even extinction.[1] It may prove helpful to think of this as 'Risk of Collapse + GCR + Extinction' cumulatively.*
Global Catastrophic Risk (GCR)	*The probability of a loss of 25% of the global population and the severe disruption of global critical systems (such as food) within a given timeframe (years or decades).*
Risk	*The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems, and species.*
Societal Collapse	*The severe, relatively rapid, and/or enduring loss of an established level of population density, energy capture, and coordination.*
ASRS	*Abrupt Sunlight Reduction Scenarios. This refers to sudden events where solar is suddenly reduced, affecting issues like food security and agricultural productivity.*
HEMP	*High-altitude Electromagnetic Pulse. A detonation of a nuclear weapon at high altitude or in space, which can generate an electromagnetic pulse (EMP).*
SCP	*Single Cell Protein. This is a protein source derived from microorganisms, such as bacteria, algae, fungi, or yeast. These microorganisms are cultured and harvested for their protein content, which can be used as a food ingredient or as animal feed.*

3. Horizon Scanning Process

The horizon scan followed the **Investigate, Discuss, Estimate, and Aggregate (IDEA) Protocol** (Hanea et al., 2017). This is a structured expert elicitation method based on

[1] We are using it as an umbrella term for GCR, XR, Collapse, and protracted stagnation limiting future potential.

the systematic scoring of issues and their solutions, to determine the significance of issues, and the effectiveness of solutions, according to expert opinion. This is in addition to comparing the ranking of scores against each other.

An initial set of 21 issues and their associated solutions were submitted. These were scored anonymously on a 1–1000 scale. Rank scores were calculated by ordering each participant's responses and taking the mean score across participants, and median ranking. Based on this, a shortlist was produced.

After merging overlapping issues, 10 were shortlisted, with 2 additional issues included as "honourable mentions" based on their novelty.

Table 2 - Final shortlist of issues and their solutions, including scoring and ranks

Issue Title	Solution to issue	Issue mean score	Solution mean score	Issues median rank	Solution median rank
Humanitarian logistics	Humanitarian logistics preparedness localisation	744.375	753.4285714	2.5	6
	build up local or regional stockpiles and preposition supplies in various locations to be deployed when and where needed		750.7142857		7
Supply chain disruptions	Reduction in the amount of food waste and food fed to animals	856.625	679.2857143	3.5	8
	Development of alternative foods		721		9
	Global diversification of supply chain hubs that facilitate food distribution.		825.4285714		3

	Transport route diversification within countries		654.8571429		17
Transport disruptions	More decentralised global transport networks	783	732.8571429	6	15
Breakdown of food systems / agrarianism		708.375		6	
Health system crisis and generational trauma	Enhancing self-sufficiency at national levels	770.5	843.2857143	6	12
Agricultural systems are unprepared for the depletion of the stratospheric ozone layer as a compounding risk in a nuclear winter	Bio-engineering of existing crops, to prioritise the production of UV-screening compounds		824.5714286		11
	Preparations to use seaweed to replace significant portions of human diets globally	772.875	824	6	12
Institutional breakdown of nuclear arms control	Establishment of gender-sensitive civil defence and recovery frameworks	654.5	776.8571429	10	16
Emerging geopolitical power shifts	Agroecological Regenerative Agriculture Transition Acceleration		787.4285714		12
	Bioregional Food Governance Structures		732.8571429		16
	Integrated Food Systems Data Infrastructure	743.875	753.2857143	10.5	13

	Resilient Food Production Knowledge Commons		803.7142857		11
	Resilient Seed Systems		807.4285714		11
Local Knowledge Systems Collapse as Critical Threshold for Recovery Capacity	International Certification Standard: Food Systems Infrastructure and Recovery	751.125	724.7142857	10.5	13
Political extremism / nationalism post-strike	Strengthening of local social infrastructure	751.125	733.2857143	10.5	19
High-latitude sea ice and port disruption **(honourable mention)**	Polar class vessels	645.5	613.5714286	12.5	23
AI integration into NC3 systems **(honourable mention)**	Embedding safeguards and Fail-Safe protocols in AI-enabled NC3 systems	605	699.2857143	14	14

4. Horizon Summit (Culminating event)

Using futures methodologies such as scenario, stakeholder and domain mapping, stress testing and back casting, the Summit explored cascading pathways, systemic interactions, and long-term solutions in the medium-long term aftermath of a nuclear strike.

The Horizon Summit thus provided a structured deliberative space to translate the horizon scan findings into actionable insights, connecting technical risk assessment with participatory policy design. This final stage ensured that the prioritised risks were not only identified but also situated within broader governance trajectories, intergenerational considerations, and pathways toward systemic resilience.

Figure 1 summarises the entire horizon scan and solution process, including the culminating Horizon Summit.

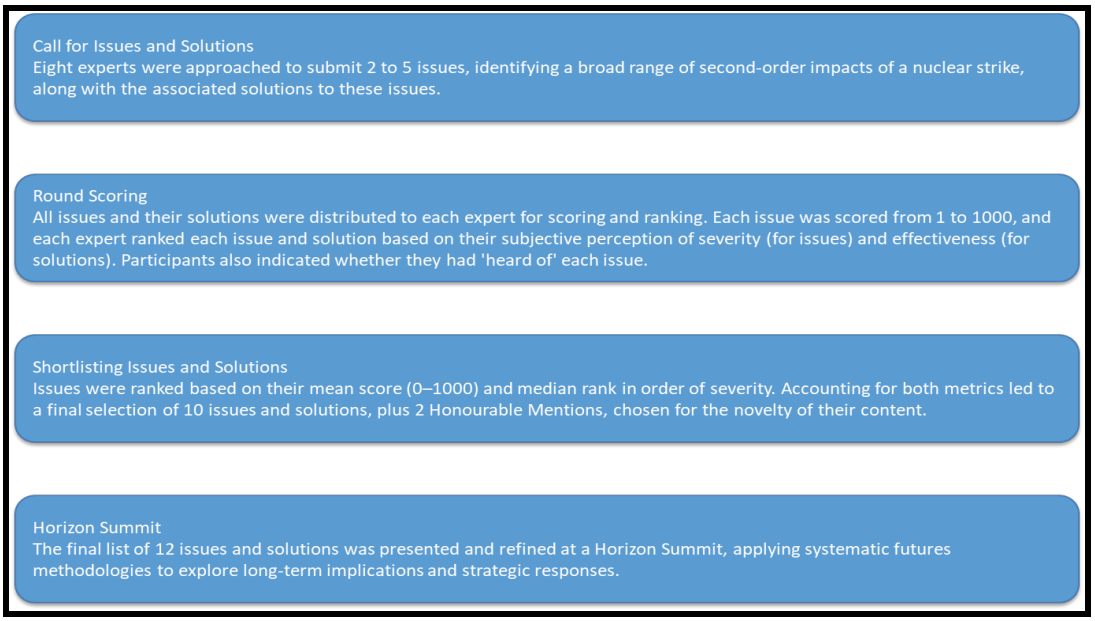

Figure 1 - An overview of the Horizon Scan and solution process, including the culminating event of a Horizon Summit

The Horizon Scan served as a structured foundation for identifying and prioritising risks and solutions in the aftermath of a nuclear strike, using the IDEA Protocol to elicit expert judgement through systematic scoring and ranking (see Hanea et al., 2017). This process distilled a broad set of 21 issues into a focused shortlist of 10, with two additional novel concerns included as honourable mentions. These honourable mentions were determined by the lowest scoring issue of a ‘heard of?’ variable participants had to answer for each issue in the horizon scan. The issues with the two lowest scores in this variable were nominated as the honourable mentions.

By quantifying expert consensus and aggregating rankings, the scan produced a data-driven map of critical vulnerabilities and potential interventions; effectively setting the agenda for deeper strategic exploration.

Building directly on these findings, the Horizon Summit employed futures methodologies, such as scenario development, stakeholder and domain mapping, stress testing and back casting — to interrogate the systemic implications of the shortlisted risks. The Summit translated the scan’s technical outputs into actionable insights by embedding them within deliberative policy design and long-term governance trajectories. This methodological linkage ensured continuity between expert elicitation and participatory foresight, allowing the Summit to extrapolate cascading pathways and resilience strategies that were both grounded in evidence and responsive to intergenerational and cross-sectoral concerns.

This sequential design, moving from structured expert elicitation to participatory foresight, ensured that the Horizon Summit did not merely validate the scan's findings but actively stress-tested them against plausible future conditions. This methodological continuity strengthened the credibility and relevance of the final recommendations, bridging technical rigour with strategic foresight.

Outlining and justifying the novel 'Horizon Summit' methodology

As per Figure 1, a novel Horizon Summit method was applied to analyse each shortlisted issue, and prognosticate their futures under different scenarios. This was done in 2 separate workshops with all 8 experts, who analysed each shortlisted issue and solution outlined in Table 2 through the prism of the Horizon Summit.

The Horizon Summit methodology is inspired by notable horizon scanning literature, such as Joseph Voros' Futures Cone (Voros, 2003), the 3 Horizons Framework (Sharpe et al., 2016; Curry & Hodgson, 2008) and Andy Hines' environmental scanning tool (Hines et al., 2022). Figure 2 is the heuristic for the Horizon Summit, and Figure 3 is a summary of the methods and workshops that comprise the Horizon Summit.

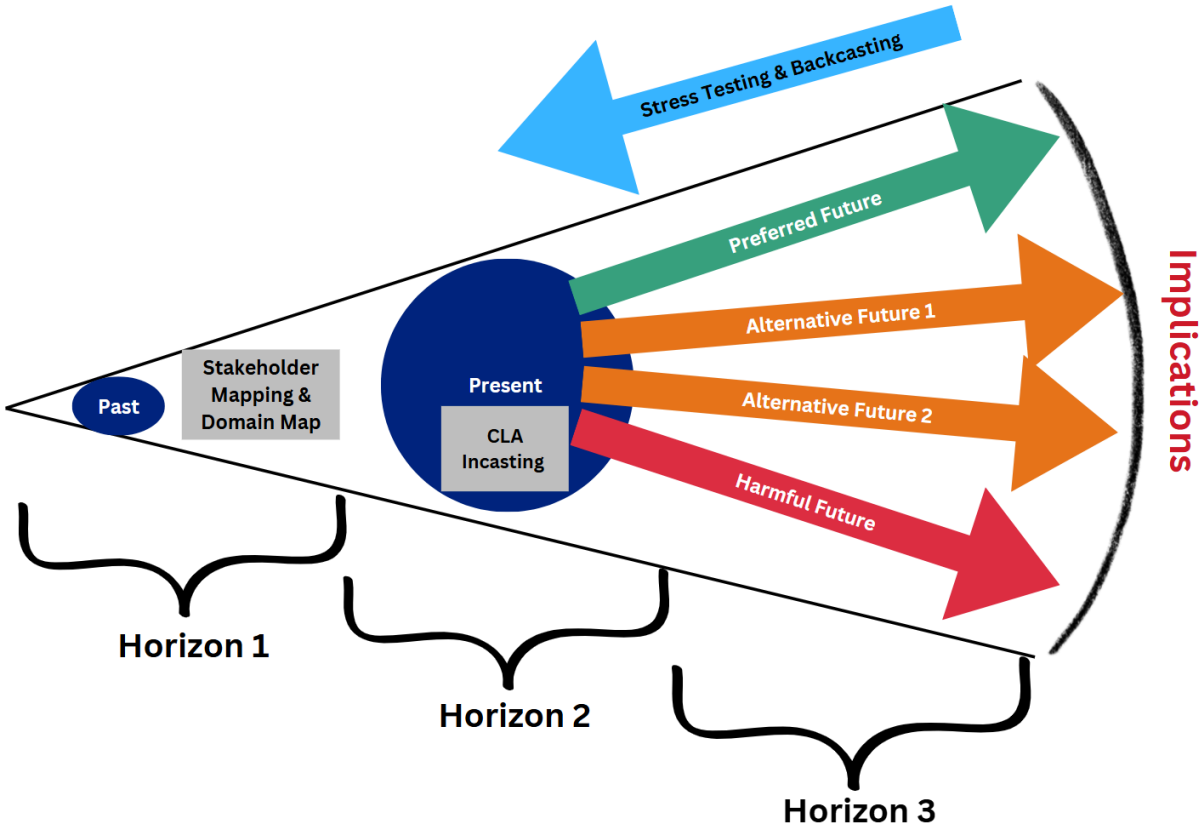

Figure 2 - The Heuristic of the Horizon Summit

Contemporary policy environments are increasingly characterised by disruption, complexity, and uncertainty (Boin, 2009; Boin, 2014). Converging tipping points across economic, environmental, technological, and political domains generate cascading and often unpredictable effects, complicating the governance of complex systems (Spitz & Zuin, 2022; Whiting & Parker, 2023). Decisions taken under such conditions have enduring implications, influencing economic structures, social cohesion, environmental sustainability, and the protection of civil liberties.

Despite this, policy decisions made in the present delimit the scope of future possibilities, embedding path dependencies that either constrain or enable the capacity of subsequent generations to respond to emerging risks (Goldstein et al., 2016; Feduzi et al., 2022).

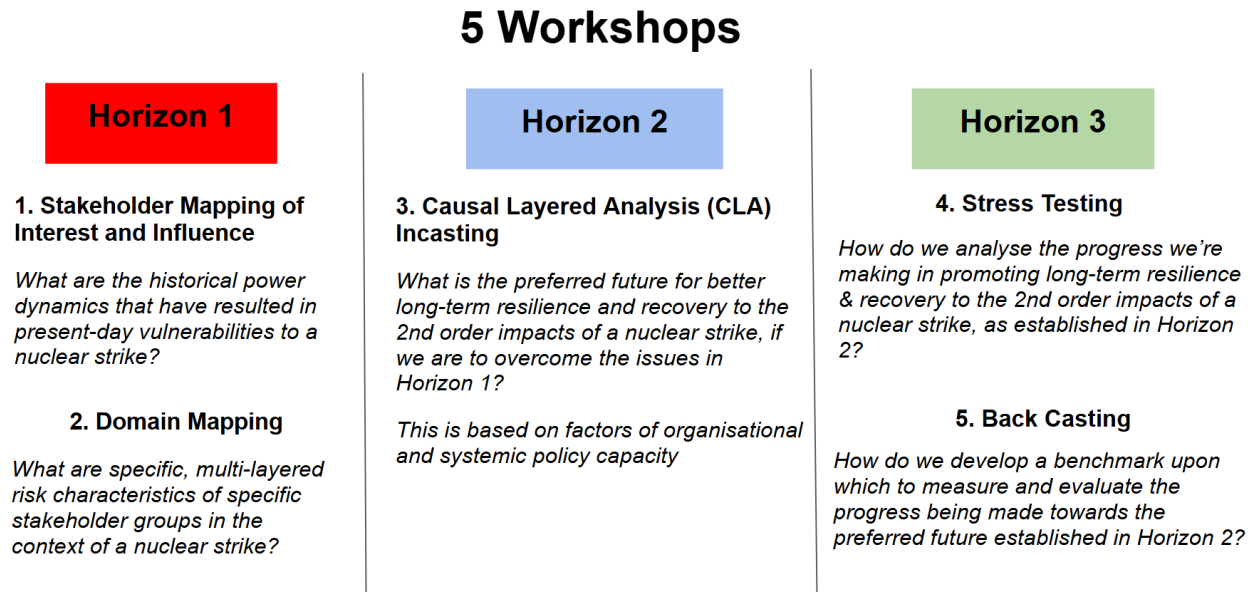

Figure 3 - A summary table of workshops and methods in the Horizon Summit

As such, the Horizon Summit encompasses principles of Inayatullah's 'six pillars' framework for futures (Inayatullah, 2008), which implores the need to look beyond futures that seem predetermined (the 'used' future), but instead actively consider the 'disowned' futures that are often seen as preposterous or implausible (also explored by Voros, 2003) - both in the positive and negative sense.

Horizon Summits convene a wide spectrum of voices, to collectively map and interrogate these complex consequences through the lens of the 3 Horizon Framework (Sharpe et al., 2016; Curry & Hodgson, 2008). When analysing the 2nd order impacts of a nuclear strike, this involves:

- **Horizon 1 (Historical factors):** Participants examine the historical and institutional context of nuclear governance, the vulnerabilities within existing security architectures, and the direct and immediate consequences of a strike. This includes mapping current governance dysfunctions, institutional fragilities, and the inadequacy of “business-as-usual” emergency response planning.

- **Horizon 2 (Present Factors, and Transition Zone):** The focus here shifts to identifying potential societal trajectories in the wake of a strike. Scenario mapping is used to explore divergent futures — ranging from authoritarian securitisation and geopolitical fragmentation, to cooperative resilience-building and renewal of global governance. Participants collectively define a *preferred policy future* for navigating the aftermath, while also clarifying what alternative, harmful futures may emerge if 2nd order impacts are mishandled, against factors of organisational and systemic policy capacity.

- **Horizon 3 (Long-Term Future):** Using backcasting and stress testing, participants chart pathways to their preferred future, identifying critical leverage points and interventions needed to mitigate cascading risks. Horizon 3 also stress tests and backcasts the alternative futures and the harmful future - providing a way to monitor what future we are on a trajectory towards in the long-term. As such, Horizon 3 emphasises the monitoring of qualitative indicators, such as levels of institutional trust, patterns of migration, ecological regeneration, or resilience of supply chains. These signal whether society is trending towards renewal or deeper collapse.

The heuristic in Figure 2 provides a broad trajectory of futures, acknowledging the several trajectories that could comprise the future (Horizon 3 possibilities, or solutions), but also the historical factors that underpin these trajectories - as it is naive to be ahistorical about the future (Inayatullah, 2008). Hence, that is the purpose of Horizon 1 - analysing the historical power imbalances that provide precedent that could determine multiple futures for the solutions identified by the 8 experts. Horizon 1 uses the stakeholder mapping framework of Cairns & Wright (2018) to determine who the ‘subjects’ are in the power dynamics of nuclear risk, in relation to the ‘context setters’ and ‘players’ - when benchmarked against factors of power and interest (see Figure 4).

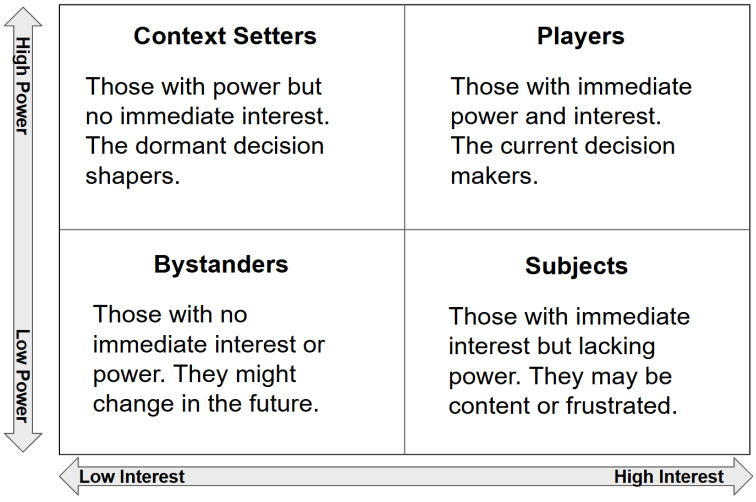

Figure 4 - The power and interest dynamics that determine power imbalances and relationships in any policy environment (Cairns & Wright, 2018).

Building upon the historical characteristics determined in Horizon 1, Horizon 2 of the framework provides 4 scenarios (through a 2x2 matrix) that determine the long-term trajectory that 'subjects' may experience as a result of 2nd order impacts of a nuclear strike. This is based on factors of organisational policy capacity (the ability for governments and institutions to maintain legitimacy and capability after a nuclear strike), and systemic policy capacity (the ability for society-at-large to generate an authorising environment for long-term resilience and cohesion) (see Wu et al., 2015; Howlett & Ramesh, 2016). Figure 5 shows more information about this.

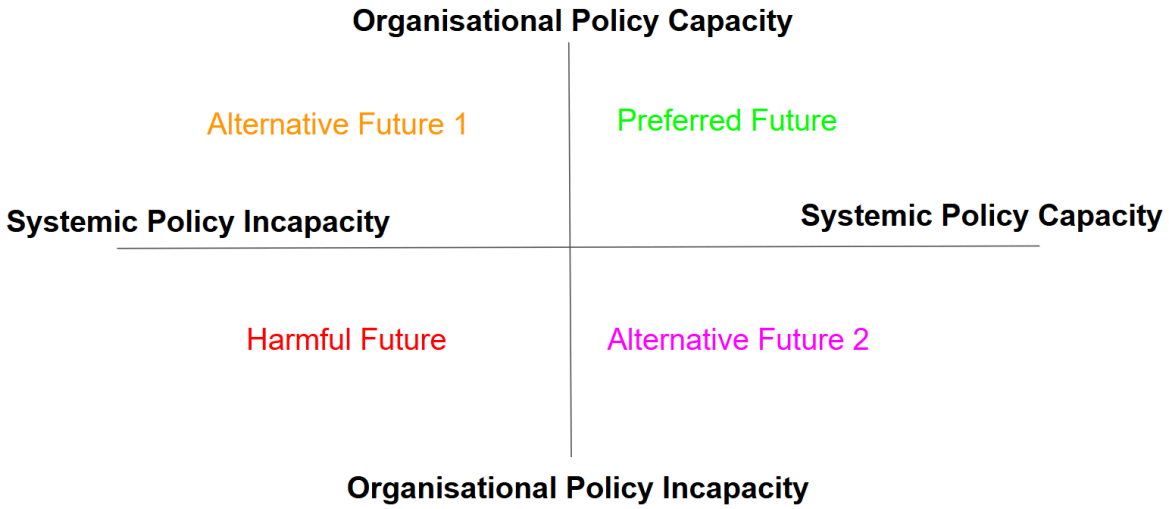

Figure 5 - 2x2 scenario map of different futures of their 'subjects', as determined in Horizon 1 (Workshop 1)

Each scenario was analysed through Inayatullah's Causal Layered Analysis (CLA) (Inayatullah, 1998), which assesses each scenario by its underlying systemic factors, and the worldviews that drive these systemic factors (see Figure 6). This offers a depth of analysis to each scenario, not just breadth.

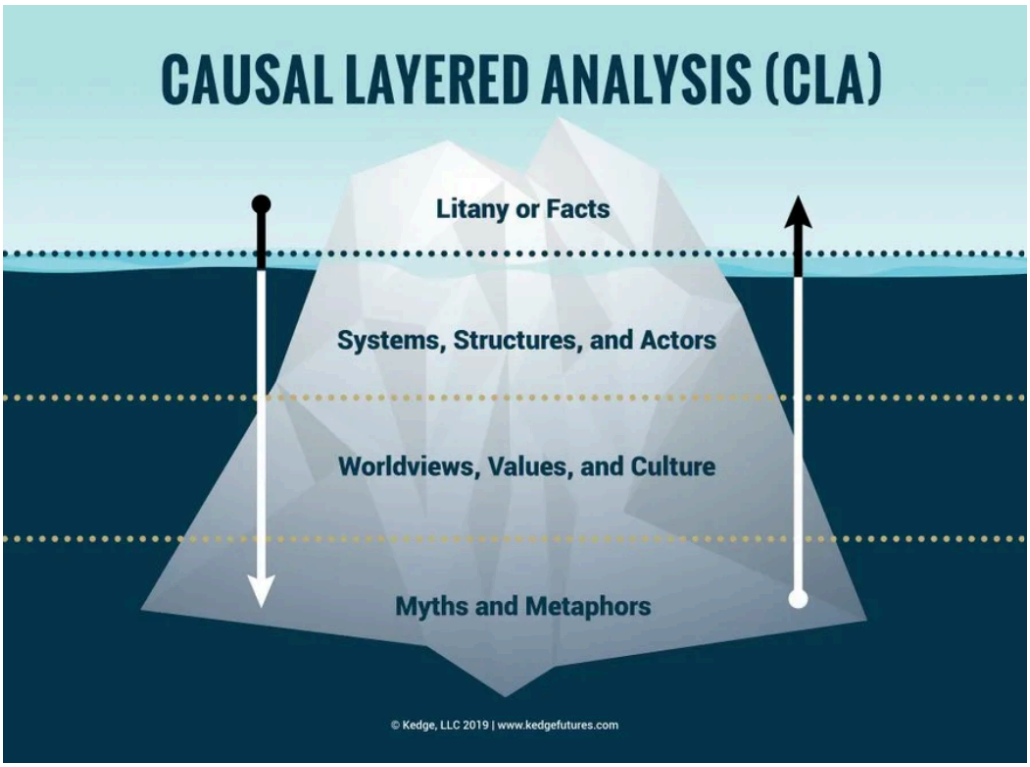

Figure 6 - Causal Layered Analysis framework (Inayatullah, 1998)

Finally, stress-testing and backcasting methods are used to assess each of these scenarios against factors of 'resilience' (Roberts, 2023). There factors of resilience are the (in)ability for a solution to **absorb** disruption to its trajectory, **adapt** to disruption and **transform** (recover) over time — ultimately being antifragile (see Taleb, 2014). Hence, Horizon 3 determines what would lead to long-term success, or failure, of solutions in the context of 2nd order impacts of a nuclear strike.

The Odyssean Institute's Horizon Summit methodology is designed to address short-sightedness and parochialism in policymaking. It combines deliberative engagement with structured futures thinking, enabling participants to situate historical and immediate concerns within longer-term trajectories. By organising perspectives across multiple time horizons, the methodology clarifies trade-offs, identifies leverage points, and supports the development of policy pathways that are both resilient and intergenerationally just. In this respect, Horizon Summits provide a systematic and

future-oriented framework that enhances the inclusivity, legitimacy, and robustness of policy design under conditions of uncertainty.

As Kingdon's Multiple Streams Framework suggests, durable change requires *policy entrepreneurs* who can seize *policy windows* (Kingdon, 2011; Howlett et al., 2016). Horizon Summits provide a deliberative infrastructure for this role, legitimising collective problem-framing and generating actionable insights. Crucially, they also advance the often-neglected task of policy translation.

Applied to nuclear governance, Horizon Summits move beyond immediate impacts to design anticipatory responses to order effects. By embedding diverse perspectives and clarifying policy levers, they enhance both the legitimacy and resilience of institutional decision-making.

Results

Initial Horizon Scan

Table 2 outlines the final shortlisted issues and their associated solutions.

A summary of these issues and solutions is as follows:

Issue 1: Humanitarian Logistics in the Aftermath of a Nuclear Strike

The humanitarian consequences of a nuclear strike are among the most compelling arguments for nuclear disarmament (Borrie, 2014; Ritchie, 2024). The anticipated scale of civilian casualties is deeply unpopular with the public, even among those who may support conventional military action (Smetana & Onderco, 2023). A joint statement by the International Federation of Red Cross and Red Crescent Societies and the International Committee of the Red Cross (ICRC, 2025) emphasises that no humanitarian organisation could adequately respond to the scale of need following such an event.

Accessing affected populations would be severely hindered by radioactive contamination, delaying aid even if supplies and personnel were available. The cascading effects of a nuclear strike — such as environmental degradation and societal collapse — would exacerbate humanitarian needs far beyond the immediate blast zone (ICRC, 2025). Global food insecurity would rise sharply, particularly affecting already vulnerable populations (Helfand, 2013). Refugee movements would likely reach unprecedented levels, and traditional donor countries in the Northern Hemisphere could

themselves face mass starvation due to nuclear-induced global cooling (Bivens, 2022). The scale of humanitarian logistics required would be without precedent.

Solution: Localised and Scalable Humanitarian Preparedness

Addressing such challenges will require significant political will and investment. Humanitarian logistics must prioritise localisation - building regional stockpiles and pre-positioning supplies to ensure rapid deployment (Frennesson et al., 2021). These efforts should complement national reserves, particularly for critical items like medicines (World Health Organization, 2023).

Given the likely global scale of need, international cooperation will be essential. However, the current humanitarian system is already under strain and underfunded (Development Initiatives, 2024). A nuclear strike would not only create new crises but also worsen existing ones, demanding a fundamental rethinking of humanitarian logistics capacity and funding models which are currently already under severe strain due to the withdrawal of the USA and other countries from many development and humanitarian aid obligations.

As immediate, lower-cost steps, governments and NGOs could:

- Pilot “micro-hubs” of pre-packed essential supplies within existing community facilities, such as schools or local health clinics, which would reduce storage and transport costs while dramatically improving first-wave response times.

- Create neighbourhood-level volunteer logistics teams, trained in basic inventory management and distribution, to supplement professional responders during the first critical days after a strike.

- Pre-position mobile, solar-powered cold-storage units (EMP hardened) at regional health posts to maintain essential medicines and vaccines when grid power fails, reducing spoilage and extending the reach of emergency health care.

These small but practical interventions provide an affordable bridge between everyday preparedness and the large-scale systems needed for full humanitarian response after a nuclear strike.

Issue 2: Disruption of Supply Chains Following a Nuclear Strike

A nuclear strike would cause widespread disruption to global supply chains, particularly those related to food. Agricultural zones could be directly destroyed, while infrastructure

damage would affect every stage of the supply chain—from farms and processing facilities to distribution and retail (McMahon, 2016). Even food produced outside the blast radius may be rejected due to fears of radioactive contamination. Additionally, nuclear war-induced atmospheric soot could significantly reduce global agricultural productivity (Xia et al., 2022; Bivens, 2022). In such a scenario, reliance on food stockpiles would increase, but these would likely be insufficient for prolonged disruptions (Baum & Barrett, 2018).

Beyond food, supply chains for essential goods such as sunscreen and energy would also be affected. This would heighten health risks, particularly for outdoor workers exposed to increased ultraviolet radiation, and compromise critical services like healthcare (Baum & Barrett, 2018). The interconnected nature of global trade means that a strike on an industrial hub could trigger cascading failures across multiple sectors.

Solution: Building Resilient and Adaptive Supply Chains

To mitigate these risks, several strategies have been proposed.

To mitigate catastrophic supply chain disruptions following a nuclear strike, resilience measures must move from broad principles to concrete, sequenced interventions. Reducing food waste and diverting animal feed to human consumption can substantially increase available calories, but only if designed as an emergency activation mechanism rather than a permanent peacetime reduction. Governments should therefore develop national “emergency nutrition protocols” that pre-authorise the diversion of animal feed and by-products to human food in a declared crisis, backed by stockpiled processing technologies, safety standards and training exercises with major producers to practise rapid conversion under tight timelines (Denkenberger & Pearce, 2014). This approach preserves current supply in peacetime yet allows governments to trigger diversion within weeks of catastrophic loss of food access, maximising resilience rather than prematurely constraining supply.

Alternative foods such as mushrooms grown on biomass, microbial proteins and seaweed offer promise because they can be produced independently of sunlight and conventional agriculture, but they remain untested at scale (Winstead & Jacobson, 2022). Policymakers can address this gap by creating pilot production facilities in multiple regions now, negotiating advance procurement contracts similar to vaccine “advance market commitments” and investing in public awareness campaigns to normalise non-traditional foods. These measures would shorten the ramp-up time from years to months if traditional agriculture failed due to atmospheric soot and other nuclear-induced shocks (Xia et al., 2022; Bivens, 2022).

More broadly, supply chains must shift from efficiency to adaptability. The COVID-19 pandemic showed how fragile centralised systems are when stressed (Wieland & Durach, 2021). Policymakers should map critical dependencies in food, health, energy and manufacturing supply chains, identify single points of failure and incentivise regional manufacturing clusters, distributed warehousing and mutual-aid pacts with neighbouring countries (Leng et al., 2023). The means to achieve these manufacturing clusters include government grants & subsidies, changing procurement and tendering practices to prioritise sovereign manufacturing, and R&D expenditure (Phillips & Koh 2024).

Taken together, these steps create a clear pathway from pre-crisis planning to rapid post-crisis activation, directly linking each intervention to the risks of supply chain collapse after a nuclear strike.

Issue 3: Disruption to Transport Infrastructure and Global Trade

The impact of a nuclear strike on transport infrastructure is not fully understood, but is expected to be severe due to the destructive power of nuclear weapons (Frankel et al., 2013). Such an event would significantly disrupt global transport flows, particularly in today's highly interconnected networks (Ivanov, 2017). Damage would occur both locally through direct blasts and more widely, via firestorms or water displacement, which could devastate maritime infrastructure such as ports (Frankel et al., 2013). The location of the strike is critical; for instance, an attack on a major hub like New York City could have global repercussions (Baum & Barrett, 2018).

Transport bottlenecks, especially maritime 'choke points' like the Suez and Panama Canals or the Straits of Hormuz and Malacca, are particularly vulnerable, especially if the transport infrastructure facilitating end-to-end logistics gets destroyed or damaged in a nuclear strike (Avram, 2012). Recent disruptions — such as the 2022 Suez Canal blockage and ongoing issues in the Red Sea and Panama Canal — highlight the fragility of these routes (Wan et al., 2023). A nuclear strike on such a point would necessitate costly and labour-intensive restructuring of global transport systems.

Solution: Enhancing Redundancy and Decentralisation in Transport Networks

To mitigate these risks, governments must plan transport systems with long-term flexibility and resilience in mind (Pan et al., 2021). While metropolitan areas often benefit from route redundancy, this is less common in suburban and rural areas. Investment in alternative road and rail routes is essential to maintain goods movement and enable evacuations (Wang & Xu, 2022).

Globally, over-reliance on a few mega-hubs creates vulnerability. Although hubs are often geographically fixed, decentralising transport networks where possible would reduce risk. Post-strike, economic activity and freight flows may shift, requiring adaptable and restructured transport systems. Investments should favour modular, scalable infrastructure that can be repurposed or expanded quickly in response to changing needs.

At the margin, transportation spending should be strategically directed toward:

1. **Multi-modal redundancy**: Not just more roads, but diverse transport modes such as rail, inland waterways, and even aerial corridors (e.g., drones or emergency airlifts) to ensure continuity if one mode fails. Additionally, EMP resilient logistics vehicles, GPS back-ups and the ability to repair ports and rail are critical to ensuring holistic resilience. This ensures such transport modes do not just have a single point of failure, but have contingency resilience measures.
2. **Underground infrastructure**: Tunnels and subterranean rail systems offer protection from surface-level destruction and radiation. Expanding underground networks in key urban and peri-urban zones can preserve mobility post-strike.
3. **Decentralised logistics hubs**: Reducing reliance on mega-hubs by investing in regional intermodal terminals and distributed warehousing allows freight flows to reroute quickly if primary hubs are compromised.
4. **Smart transport systems**: Deploying adaptive traffic management, real-time rerouting algorithms, and autonomous vehicles can help maintain flow and support evacuation even when human coordination is disrupted. These systems must be EMP and GPS resilient.

Issue 4: Collapse of Food Systems and Enforced Agrarianism

A single nuclear strike could trigger a global food crisis. Radioactive fallout would contaminate soil and water near the impact zone, severely limiting agricultural productivity (Robock & Toon, 2012). Even regions far from the blast would suffer from reduced crop yields due to nuclear-induced climate effects, such as shortened growing seasons and lower sunlight levels (Xia et al., 2022). As international food trade collapses and domestic production becomes a priority, nations would be forced to adopt self-sufficiency strategies.

In this context, a return to agrarian lifestyles - often enforced by governments - could become a survival imperative. Urban unemployment would rise sharply, particularly in non-agricultural sectors, prompting mass migration to rural areas. This would require many non-farmers to engage in agrarian work, which may be disruptive, time-intensive

and resource-intensive. In turn, we would need to spread more knowledge, and also hope to preserve as much knowledge about agriculture as possible.

Some populations may relocate voluntarily, while others could be compelled by emergency policies to engage in farming. Over time, this shift could reshape economies, labour markets, and even national identities, with agriculture elevated as a central cultural and political ideal.

Issue 5: Collapse of Health Systems and Long-Term Psychological Trauma

In the wake of a nuclear strike, health systems would face immediate and overwhelming collapse. Hospitals in the blast zone would be rendered inoperable due to infrastructure damage, contamination, and digital system failures (Abbasi et al., 2023). Even in unaffected regions, access to essential medicines and vaccines would be severely limited due to the breakdown of global supply chains. This could lead to the resurgence of diseases once controlled through routine healthcare, such as tuberculosis, cholera, leukemia and asthma.

The psychological toll would be equally devastating. Survivors near the blast would experience mass trauma, while populations further afield could suffer from fear, guilt, and existential anxiety. Without functioning mental health services, these effects would go untreated, leading to widespread substance abuse, from remaining medical supplies and reserves. 2nd order impacts of a nuclear strike could also deplete limited medical supplies in some cases. Additionally, chronic psychological disorders will become more prevalent. Over time, this trauma would become intergenerational, reshaping communities and societies long after the initial event (Oe et al., 2021).

Shared Solution for Issue 4 and 5: Strengthening National Self-Sufficiency for Resilience

In a post-nuclear world, the collapse of global trade would expose nations to cascading failures across food, health, and industrial systems. Enhancing national self-sufficiency is therefore essential to maintaining core societal functions in the absence of international exchange.

In the food sector, boosting domestic production through sustainable, climate-resilient agriculture can reduce reliance on global markets while minimising environmental harm (Talebian et al., 2024). In parallel, investing in circular economies - focused on repair, reuse, and local recycling of critical materials - can help mitigate the impact of disrupted supply chains (Blomsma et al., 2022; Yang et al., 2023).To avoid market suppression during times of abundance, governments and industry can explore models of latent capacity—such as modular farming systems, decentralised storage and flexible labour

pools—that remain dormant or minimally active in normal conditions but can be rapidly scaled during crises without distorting market signals. One promising approach involves dual-use infrastructure—facilities that serve commercial purposes in peacetime but can be repurposed for emergency production or distribution. Additionally, public–private partnerships can help maintain readiness by subsidising standby capacity and incentivising innovation in scalable, low-footprint technologies.

For health systems, localised production and stockpiling of essential medicines and medical supplies would be vital to maintaining basic healthcare services during prolonged trade disruptions, including antibiotics, paracetamol, aspirin, metformin and antihistamines. These measures would also support mental health infrastructure by ensuring continuity of care and access to treatment. Importantly, mental health responses must account for the distinct psychological dynamics of collective survival trauma versus individual trauma. Historical studies of WWII veterans and civilians show that while soldiers often suffered from prolonged combat stress and isolation, civilians exposed to mass trauma tended to experience grief, anxiety, and depression shaped by social disruption and loss of normalcy. Incorporating lessons from post-war recovery and disaster psychology - such as the importance of early intervention and community cohesion - can help design mental health systems that are both scalable and adaptive in crisis.

Importantly, self-sufficiency does not imply isolation. It can be pursued alongside international cooperation to build redundancy and resilience into global systems. In doing so, societies can better withstand not only the aftermath of a nuclear strike but also other systemic shocks such as pandemics and climate-related disasters.

Issue 6: Agricultural Systems Are Unprepared for Ozone Depletion in a Nuclear Winter

While much attention has been given to the cooling effects of nuclear winter on agriculture (Xia et al., 2022; Coupe et al., 2019), the compounding risk of stratospheric ozone depletion remains underexplored. Smoke and halogen release from nuclear detonations could severely thin the ozone layer for 5–15 years post-conflict, increasing UV-A and UV-B radiation at the surface (Bardeen et al., 2021; Mills et al., 2014; Coupe et al., 2019). This would coincide with a period of rapid warming after initial cooling, further stressing crops. Simulations suggest this UV exposure could significantly damage plant life, particularly in tropical regions, compounding threats to global food security (Bardeen et al., 2021).

Agriculture, which would need to adapt to both a rapid cooling followed by a sudden

warming post-war, is also vulnerable to UV radiation. Some research suggests cooling increases the presence of compounds in plants that screen UV radiation (Bilger et al., 2007).

Historical Cold War modelling and contemporary simulations underscore the severity of ozone depletion and UV-B radiation in post-nuclear environments. The compounded stress of cooling, ozone loss and UV radiation suggests that agricultural resilience must go beyond temperature adaptation to include radiation shielding and biochemical protection (Bilger et al., 2007; Bardeen et al., 2021).

Solutions: Bioengineering UV-Resilient Crops and Scaling Seaweed as a UV-Resilient Food Source

To adapt, agricultural systems must prioritise crops with high levels of UV-screening compounds. Some plants naturally increase these compounds in cooler conditions (Bilger et al., 2007), but rapid post-war warming may reduce this protection. Bioengineering nutrient-dense crops to consistently produce UV-screening compounds - regardless of temperature - could help maintain yields. These seeds should be stored in global seed vaults to ensure availability in post-disaster recovery scenarios. This approach also builds resilience to other global threats like asteroid impacts of geoengineering interventions.

Likewise, seaweed, protected from UV radiation by water, offers a promising alternative. Research suggests it could meet up to 45% of global food demand within a year of a nuclear conflict (Jehn et al., 2024). However, establishing seaweed farms and ensuring global distribution would require significant pre-war planning and investment, especially given the likely breakdown of trade networks.

Issue 7: Collapse of Multilateral Nuclear Arms Control Frameworks

A nuclear detonation, whether accidental, miscalculated or deliberate, could precipitate the rapid breakdown of global nuclear arms control regimes. Treaties such as the Non-Proliferation Treaty (NPT) and the Comprehensive Nuclear Test Ban Treaty (CTBT), along with their verification mechanisms, would face immediate credibility crises. The use of nuclear weapons would erode trust between states, dismantle monitoring infrastructure and sap political will for cooperation. This institutional collapse would not only escalate near-term risks of further detonations but also make it far harder to negotiate future disarmament or to maintain broader multilateral diplomacy (Meier, 2024). The resulting vacuum could spark renewed arms races, encourage proliferation among non-nuclear states and undermine global security well into the future.

Solution: Gender-Sensitive Civil Defence and Recovery Frameworks as a Stabilising Mechanism

Because a nuclear detonation can unravel international arms control institutions, national and local recovery measures become a crucial bridge to re-establishing stability and trust. Gender-sensitive civil defence and recovery frameworks directly address the governance gap that opens when multilateral institutions fail (Nicols & Olson, 2024). By collecting sex-disaggregated data, designing targeted health interventions for vulnerable groups and ensuring inclusive representation in emergency decision making, governments can demonstrate fairness, competence and transparency at home. This, in turn, helps maintain domestic legitimacy and international credibility at a time when global norms are weakest (Nicols & Olsen, 2024; Dimmen, 2014).

Embedding gender-responsive budgeting and planning in disaster preparedness and international response protocols signals a commitment to equity and the rule of law, countering the perception of arbitrary or discriminatory relief that can inflame tensions. Cross-sector collaboration between nuclear resilience experts and organisations experienced in gendered impacts of crises – such as climate disasters and armed conflict – strengthens recovery systems and showcases practical cooperation even in the absence of functioning treaties (International Committee of the Red Cross & European Union Institute for Security Studies, 2014). In short, these frameworks do more than protect vulnerable populations: they help rebuild social trust and institutional legitimacy, which are prerequisites for restarting arms-control negotiations and reducing the risk of renewed proliferation.

Issue 8: Geopolitical Power Shifts from Climate-Driven Changes in Arable Land

Climate change is reshaping the global distribution of arable land, with high-latitude, high-income countries projected to see significant agricultural gains due to warming (Minoli et al., 2022). These regions also possess greater access to advanced agricultural technologies, widening the gap in climate adaptation capacity (Gamage et al., 2024). Meanwhile, urban expansion continues to consume fertile land elsewhere (Liu et al., 2019). In the event of a nuclear winter or other Abrupt Sunlight Reduction Scenarios (ASRS), these disparities could deepen, leaving vulnerable populations with limited resilience to food insecurity and environmental shocks (Chan et al., 2024). Alternatively, if cooling goes in the opposite direction and is disproportionately at high latitudes, it could do the opposite (at least temporarily). Without coordinated governance, these shifts risk entrenching global inequalities in food production and crisis response.

Solutions: Accelerate Agroecological Regenerative Agriculture, Develop Bioregional Food Governance Structures and Build Integrated Systems Data Infrastructure

Establish regionally adapted regenerative agriculture hubs to decentralise food production and reduce reliance on global supply chains. These hubs would promote low-input practices like agroforestry, intercropping, and crop rotation, which enhance biodiversity, sequester carbon, and maintain yields (Food and Land Use Coalition, 2023). Reducing dependence on synthetic fertilisers would also buffer against chemical supply disruptions. Field evidence from India's Zero Budget Natural Farming shows improved yields and soil health under stress conditions (Duddigan et al., 2023).

Create nested, multi-scale governance systems that empower local decision-making while supporting global coordination. Initiatives like the Milan Food Policy Pact demonstrate how local networks can drive broader reform (Santo & Moragues-Faus, 2019). These systems should prioritise nutrition, ecological sustainability, and cultural relevance, enhancing resilience to both geopolitical and environmental shocks (Oñederra-Aramendi et al., 2023).

Develop a global, crisis-resilient food data network to eliminate blind spots in vulnerable regions. Currently, 70% of the world's population lives in countries lacking adequate food systems data (Fu et al., 2025). Real-time, subnational monitoring would enable better risk assessment and resource allocation during crises. Systems-based metrics that integrate environmental, nutritional, and social indicators improve decision-making under stress (Fanzo et al., 2020, 2024; Allen et al., 2019).

Issue 9: Collapse of Local Knowledge Systems Undermines Recovery Capacity

The rapid loss of linguistic and cultural diversity - projected to affect over 1,500 languages by century's end (World Economic Forum, 2022) - threatens the survival of traditional ecological knowledge (TEK) critical for resilience in post-nuclear scenarios. As languages vanish, so too does place-based knowledge that has enabled communities to adapt to environmental extremes for generations.

The IPCC (2023) underscores that inclusive governance incorporating Indigenous knowledge significantly enhances climate-resilient development. Without such integration, communities may lack the adaptive capacity to respond effectively to nuclear 2nd order effects, particularly in regions already marginalised by global power and resource disparities.

Solution: International Certification for Food Systems Infrastructure and Recovery

To address this gap, an international certification standard should be established to assess the resilience of food systems infrastructure - both physical and digital - under degraded conditions, including nuclear 2nd order effects. This standard would evaluate factors such as local supply chain vulnerability, reliance on specific knowledge systems, and adaptability to substitute materials (Belyakov, 2015).

Applied at local, national, and regional levels, the certification would identify critical weaknesses and guide investment in planning, monitoring, and public education. By embedding respect for diverse knowledge systems into resilience metrics, this approach ensures that recovery strategies are inclusive, context-sensitive, and better equipped to withstand complex, cascading crises.

Issue 10: Political Extremism, Nationalism, and Breakdown of International Cooperation

A nuclear strike could trigger widespread political destabilisation, fuelling extremism, nationalism, and the erosion of international cooperation. In the aftermath, damaged or overwhelmed government institutions may struggle to maintain order or provide guidance. This vacuum creates fertile ground for extremist groups - such as neo-Nazi, militia, and xenophobic movements - to gain influence and recruit members.

Social fragmentation would intensify as trust in institutions (vertical trust) and among citizens (horizontal trust) deteriorates (Aldrich, 2012; Aldrich, 2023a). Displaced populations and economic hardship could further inflame nationalist sentiment, with foreign actors scapegoated for the crisis. In such a climate, international collaboration becomes increasingly unlikely, undermining collective recovery efforts and global governance.

Solution: Strengthening Local Social Infrastructure to Rebuild Trust

To counter these risks, investment in local social infrastructure - such as parks, libraries, places of worship, and community-oriented businesses - can play a vital role in rebuilding trust and cohesion (Joshi & Aldrich, 2025). These spaces foster civic engagement, reduce polarisation, and serve as hubs for reliable information and mutual support.

However, access to such infrastructure is often unevenly distributed (Fraser et al., 2022). Expanding and equitably distributing these facilities can help communities resist

misinformation, reduce mortality during crises, and promote both horizontal and vertical trust (Aldrich, 2023a; 2023b). As such, social infrastructure is a “polysolution” - supporting resilience, social cohesion, and democratic stability in the face of systemic shocks.

Issue 11: Sea Ice Expansion Threatens High-Latitude Port Operations

A large-scale nuclear conflict would trigger abrupt global cooling, reversing over a century of warming and causing rapid sea ice expansion in high-latitude regions (Harrison et al., 2022; Coupe et al., 2023). Ports that have become increasingly accessible due to anthropogenic warming - such as Busan, Tianjin, Vladivostok, and St. Petersburg - could be encased in over a metre of sea ice for more than five years (Coupe et al., 2019). These ports, critical to global and/or regional trade, are not currently equipped to handle such conditions. If land and air transport infrastructure is also damaged, nations reliant on maritime trade would face severe logistical and economic disruptions. If we assume the US pre-emptive targeting already wants to minimise nuclear winter effects, communicating these effects to China, Russia and other nuclear powers might also make them adjust their targeting.

While these ports will have significant first-order impacts on the logistical resilience of Europe, particularly Eastern Europe and Russia, there are strong 2nd and 3rd order impacts on global trade, due to their flow-on logistical connections. Importantly, commodities such as steel, aluminium and oil flow through these ports - vital to resilience and recovery from a nuclear strike.

Solution: Adapt Port Infrastructure for Sea Ice Variability

To mitigate this risk, high-latitude ports must prepare not only for sea level rise but also for the possibility of sudden sea ice resurgence. Investing in polar-class vessels with high icebreaking capabilities - though costly - would ensure continued navigability through thick ice. This is especially for ports like St Petersburg, Vladivostok, Tallinn and Riga. More broadly, port infrastructure should be designed with greater flexibility to accommodate increased variability in sea ice conditions. By planning for both warming and abrupt cooling scenarios, nations can build resilience into critical trade infrastructure and reduce vulnerability to nuclear 2nd order effects.

Issue 12: AI Integration into Nuclear Command Systems Increases Risk of Systemic Failure

The growing integration of artificial intelligence into nuclear command, control, and communication (NC3) systems is intended to enhance early warning, threat detection,

and decision-making. However, in the event of a large-scale systems collapse - such as one caused by a high-altitude electromagnetic pulse (HEMP) or infrastructure failure - AI-enabled NC3 systems could become dangerously unreliable (Johnson, 2023).

These systems depend on stable data flows and infrastructure. Under degraded conditions, AI may misinterpret corrupted inputs, default to worst-case scenarios, or cease functioning altogether (Boulanin, 2019). Human operators may be unable to override or interpret AI decisions, increasing the risk of unauthorised launches, false positives, or decision paralysis. The opaque nature of many machine learning models further complicates accountability and crisis de-escalation (McDonnell et al., 2023). Rather than enhancing stability, AI integration could amplify the risk of catastrophic escalation during systemic shocks.

Solution: Embedding Safeguards and Fail-Safe Protocols in AI-NC3 Systems

To reduce these risks, AI-enabled NC3 systems must be designed with robust safeguards and fail-safe mechanisms. Key measures include:

- Mandatory human-in-the-loop and human-in-command protocols at all decision points involving nuclear weapons use.
- Fail-safe protocols that deactivate or constrain AI functions during signal degradation, cyber compromise, or HEMP events, assuming the AI is not just Faraday caged.
- Stress-testing AI systems against 2nd order failure scenarios, such as corrupted data or communication breakdowns. Building EMP resilience would be preferable in this circumstance.
- Internal transparency tools, such as audit logs and decision traceability, to ensure accountability and interpretability.

These safeguards should be embedded in technical standards and procurement requirements. While they cannot eliminate risk, they build adaptive capacity into fragile systems and reduce the likelihood of AI-triggered escalation in chaotic environments.

Horizon Summit

Structuring the Findings of the Horizon Summit

The Horizon Summit convened 8 experts, each focusing on a specific 2nd order impact of a nuclear strike (e.g. food security, migration, governance breakdown, etc.), and collaboratively exploring vulnerabilities (H1), preferred futures (H2), and long-term resilience solutions (H3).

Horizon 1 and 2 focused on particular issues

Horizon 3 focused on solutions to those issues.

Horizon 1: Identifying Vulnerabilities and Overcoming Business-as-Usual

Analytical focus: Historical and systemic weaknesses in governance that amplify 2nd order nuclear impacts

Workshop 1 – Stakeholder Mapping

Table 3 - Results of Stakeholder mapping for the identified 'subjects' in each issue

Issue	**Vulnerable Groups (Subjects)**	**Remarks/Details**
Humanitarian Logistics	Refugees and displaced communities.	People in countries far from the blast but traditionally dependent on humanitarian aid.
Political extremism/nationalism post strike	Individuals dependent on social and familial networks.	Those most affected by the crisis but largely dependent on others for their survival and recovery.
Emerging geopolitical shifts	Communities in climate-affected regions with declining arable land or food access - small-scale farmers, displaced populations, and low-governance regions.	People involved in agriculture in regions affected by climate-driven changes in arable land distribution.
Local knowledge systems collapse as critical threshold for recovery capacity	Scientists and researchers, those involved in the education sector - particularly due to the loss of local knowledge systems collapse.	Particularly potent impacts on long-term empirical knowledge, that is necessary for societal recovery and flourishing.
Supply chain disruptions	Precariate Labour Small-holder farmers, Factory workers, miners etc.	Particularly those in small open economies with strong welfare systems democratic

		traditions and values.
High-latitude sea ice and port disruption	Those dependent on export industries and regional/global trade, particularly within Arctic communities.	Especially harmful to communities dependent on long-term biodiversity in high latitudes.
Institutional breakdown nuclear arms control	"The Vulnerable Advocates" Civil society stakeholders that are advocating for equitable and just recovery from a nuclear strike, who still lack power.	Those who understand intimately how nuclear disasters amplify gender inequalities because they live with these vulnerabilities on a regular basis, yet lack formal power to reshape the systems meant to protect them.
Transport Disruptions	Densely Populated Urban Centers, Service-Dependent Populations.	Fragile State Citizens. LMIC populations (low power / highly affected) Coastal Populations, Port Workers. Migrant worker in a bustling city whose entire livelihood and ability to send money home depends on a functioning economy.
AI Integration into NC3 systems	Anyone who is the victim of an AI initiated/provoked nuclear war, including agricultural workers.	This might include immigrants who spend long days manually harvesting crops in adverse weather, where their entire livelihood is directly tied to robust agricultural yields.
Health system crisis and generational trauma	Individuals with health co-morbidities, including disabled and elderly populations.	Individuals with co-morbidities that also have limited social networks are particularly vulnerable.
Agricultural systems are unprepared	Those dependent on	Particularly in jurisdictions

for the depletion of the stratospheric ozone layer as a compounding risk in a nuclear winter	agricultural economics, particularly subsistence farming	without adequate supply chains and logistics, to compensate for the lack of local food production.
Breakdown of food systems/agrarianism	Smallholder farmers, day labourers in the agricultural sector.	Forgotten frontline who are most affected and most engaged, yet least heard or supported. They are fighting for their own survival and against systemic neglect.

The analysis of ‘subjects’ in the 2nd order impacts of a nuclear strike reveals a strikingly consistent pattern: those most deeply affected are the “subjects” of global systems - populations with high interest in outcomes but limited power to influence them. These groups are characterised by structural precarity, dependence on fragile infrastructures, and systemic exclusion from decision-making processes.

Agricultural workers and smallholder farmers emerge as central actors in this landscape. Their livelihoods are directly tied to ecological stability and arable land and all of which would be profoundly destabilised in a nuclear winter scenario. Agricultural workers that can prove more resilient will produce a surplus of food and be in high-demand, potentially having higher wages. However, subsistence agriculture will be significantly impacted Yet, despite their indispensable role in food production and survival, they remain politically marginal and poorly resourced in governance structures. Similarly, displaced populations, migrants, and urban service workers - many reliant on remittances, humanitarian aid, or fragile labour markets - embody the vulnerability of those whose existence is contingent upon external flows of goods, services, and capital. Additionally, they also have minimal direct bargaining in the aftermath of a nuclear crisis.

Health-dependent populations, including the elderly and chronically ill, illustrate another layer of fragility. Their survival depends on complex medical systems that would rapidly erode under post-strike conditions, transforming individual vulnerabilities into intergenerational trauma. Alongside these are communities of knowledge - scientists, educators, and grassroots advocates - whose expertise and lived experience are vital to resilience, yet systematically undervalued or ignored in institutional responses. If they were valued, more robust evidence-based decision making would be possible, leading to more targeted and deliberated policy responses.

These findings highlight that vulnerabilities to 2nd order nuclear impacts are less a function of exposure alone than of critical dependencies and power asymmetries.

Populations whose survival depends on transnational supply chains, humanitarian regimes, or fragile health systems are precisely those least able to shape their continuity. This structural imbalance creates a paradox: those most essential for recovery—food producers, caregivers, knowledge-holders—are also those who exhibit the factors of vulnerability. In this sense, a nuclear strike would not only generate acute humanitarian crises but also magnify the chronic inequities that organise the global distribution of risk and resilience. While the first order impacts of a nuclear strike might affect different demographics more equally, the 2nd order impacts will be unevenly distributed, in accordance with the factors of vulnerability.

Workshop 2 – Domain Mapping

Workshop 2 involved all participants to identify the 'threat', 'exposure' and 'vulnerability' factors of each of their subjects, as per the definition of Roberts (2023):

- *Threat* - refer to the seriousness of an **external** threat associated with the 2nd order impacts of a nuclear strike
- *Exposure* - refers to whether a particular part of a person's **external** environment will exacerbate the impacts of the 2nd order impacts of a nuclear strike
- *Vulnerability* - refers to the **personal** (internal) characteristics of a person that are likely to exacerbate the 2nd order impacts of a nuclear strike (i.e. socio-economic status, age, gender, etc).

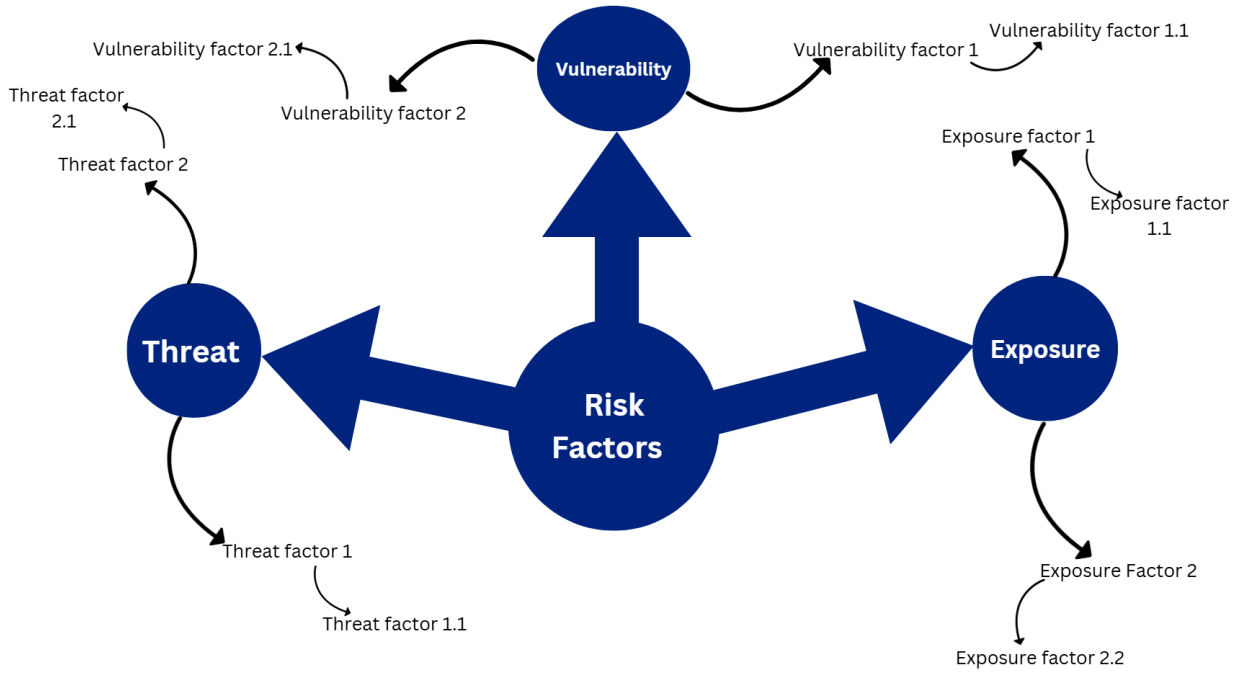

Figure 7 - Domain mapping method visualised

Some common themes emerged:

The 2nd order impacts of a nuclear strike are not confined to the immediate devastation of the blast. They cascade through global food systems, trade networks, humanitarian supply chains, and health infrastructures, creating overlapping layers of risk. Understanding these dynamics requires an integrated view of **threats, exposure, and vulnerabilities**, which together determine how hazards translate into social crises. This perspective aligns with Wisner et al.'s (2004) *Pressure and Release (PAR) model*, which shows how root causes, dynamic pressures, and unsafe conditions converge, and Turner et al.'s (2003) vulnerability framework, which emphasises the coupled interactions of environmental and social systems.

The threats posed by a nuclear strike are inherently systemic: agricultural collapse due to nuclear winter or ozone depletion, breakdowns in health systems, and the disruption of humanitarian logistics and trade flows. Yet their impact depends heavily on the degree of exposure of different populations. Subsistence farmers and smallholder agricultural workers, for instance, are directly exposed to ecological shocks that undermine yields. Their limited financial reserves, political marginalisation, and dependence on external inputs render them highly vulnerable, with little scope to adapt. In the PAR model, their situation illustrates how root causes (agrarian dependency, inequitable land relations) combine with dynamic pressures (climate stress, global trade

reliance) to produce unsafe conditions. It is possible that those without agricultural knowledge, living in countries dependent on mechanised agriculture, are more susceptible to the 2nd order impacts of a nuclear strike on agriculture.

Similarly, displaced populations, refugees, and urban service workers experience the intersection of threat, exposure, and vulnerability in acute ways. The collapse of remittance flows, border closures, or interruptions to humanitarian aid magnify the external threat, while their exposure is heightened by insecure housing and reliance on fragile economies. Their vulnerabilities —whether arising from legal precarity, low socio-economic status, or social exclusion—mean that they lack both voice in decision-making and access to safety nets, reinforcing systemic neglect in recovery efforts. Turner et al.'s (2003) framework helps to capture this dynamic, showing how exposure to external shocks interacts with personal and structural vulnerabilities to shape outcomes.

Health-dependent populations, such as the elderly or chronically ill, provide another illustration. The threat of health system collapse directly intersects with exposure to fragile medical infrastructures, particularly in peripheral economies. Their vulnerability is compounded by age, illness, and dependence on caregiving networks, which are often themselves overstretched or undervalued. This interplay of systemic fragility and personal characteristics exemplifies how 2nd order nuclear impacts are amplified through social inequalities.

Taken together, the seriousness of the threats, the uneven geography of exposure, and the structural vulnerabilities of marginalised groups produce a landscape of compound risk. It is not any one dimension—environmental hazard, systemic disruption, or social fragility—that explains the disproportionate suffering of these populations, but rather the way they interlock. A nuclear strike thus acts as a catalyst that magnifies pre-existing inequities: those most essential for societal recovery— farmers, caregivers, knowledge-holders— are simultaneously those most exposed to cascading threats and least empowered to shape protective responses Fukuyama (2014). In this sense, the vulnerability frameworks of Wisner et al. (2004) and Turner et al. (2003) are particularly valuable, as they underscore how crises emerge not solely from hazards themselves but from the unequal distribution of power, resources, and resilience.

Horizon 2: Designing Preferred Futures

Analytical focus: Medium- to long-term systemic factors and policy capacities that could build resilience

Workshop 3 – Causal Layered Analysis (CLA) incasting

Experts constructed four scenario types, detailing them using CLA (Inayatullah, 2008). This was parameterised by variables of organisational and systemic policy capacity (Wu et al., 2015), as per Figure 4.

Common themes emerged regarding what these futures might look like, for each participant's 'subject'.

Note: the vignettes presented in this section are purely illustrative and not representative. The authors acknowledge the diversity of personas that could possibly portray these vignettes, recognising that in reality, systemic policy (in)capacity and power asymmetries are determined by an array of variables, and influence different stakeholder groups in unique ways.

Futures of Vulnerable "Subjects" after the 2nd Order Impacts of a Nuclear Strike

Mapping the possible long-term futures of vulnerable "subjects" in the aftermath of a nuclear strike onto a 2×2 matrix of systemic policy capacity (the societal willingness and enabling environment for policy action) and organisational policy capacity (the ability of public institutions to design and deliver effective policy) provides a nuanced framework for thinking through pathways of resilience and breakdown.

When analysed through this lens, it becomes evident that the fate of groups such as smallholder farmers, displaced populations, migrants, and health-dependent individuals hinges not only on material threats, exposure, and vulnerabilities but also on the interplay of institutional expertise and social legitimacy. This mapping resonates with Wisner et al.'s *Pressure and Release (PAR) model* (2004), which conceptualises disasters as the intersection of hazards and vulnerabilities, and Turner et al.'s (2003) vulnerability framework, which emphasises coupled human–environment systems. Bringing in Sohail Inayatullah's *Causal Layered Analysis (CLA)* further illuminates the deeper systemic and worldview narratives shaping each quadrant.

1. Harmful Future: Low systemic policy capacity, low organisational policy capacity

In the absence of both institutional expertise and social legitimacy, subjects face abandonment. Public institutions lack resources to craft or implement recovery measures, while society at large is fragmented, distrustful, or paralysed. Food insecurity intensifies, health systems collapse, and displaced populations are left without protection.

Vignette: *A migrant worker in a coastal city, loses her job after ports close and trade collapses. With remittance flows halted and no welfare state to fall back on, their family slips into extreme poverty. Local aid is sporadic and tainted by corruption, while*

neighbours retreat into self-interest. They are left adrift in a context where neither state nor society provides support.

At the **systemic layer**, institutional breakdown and loss of legitimacy dominate. The **worldview layer** is shaped by fatalism and exclusionary nationalism, normalising the neglect of the most vulnerable.

2. Alternative Future 1: High organisational policy capacity, low systemic policy capacity

Here, governments possess technical expertise and resources but lack broad societal buy-in. Policy interventions may be sophisticated—covering agricultural recovery, food subsidies, or health services—but legitimacy deficits prevent effective implementation. Vulnerable groups may receive temporary relief but remain alienated from policy processes, while mistrust creates uneven outcomes.

Vignette: *A smallholder farmer is offered drought-resistant seeds through a new agricultural programme. While technically sound, the programme is mistrusted: neighbours recall earlier experiences of corruption and perceive the intervention as donor-driven. They participate, but are socially stigmatised, reinforcing his isolation despite potential material benefits.*

Systemically, this reflects weak social capital and political polarisation. At the worldview layer, mistrust dominates—"the state is not for us"—producing disjuncture between technical capacity and lived legitimacy.

3. Alternative Future 2: Low organisational policy capacity, high systemic policy capacity

This quadrant reverses the imbalance: society demonstrates cohesion and solidarity, but governments lack the expertise to channel collective energy effectively. Community groups, cooperatives, and local knowledge-holders step in to fill the vacuum, creating short-term resilience but uneven long-term outcomes.

Vignette: *A subsistence farmer joins neighbours to pool food stores and re-establish seed banks. Mutual aid flourishes, drawing on traditions of reciprocity. However, when disease spreads, the absence of functioning health systems forces reliance on improvised remedies. While solidarity sustains the community initially, systemic fragility and resource scarcity threaten longer-term resilience.*

At the **systemic layer**, this reflects strong norms of reciprocity and shared survival. At the **worldview layer**, solidarity is central—"we recover together." Yet without organisational scaffolding, such efforts risk exhaustion and inequity.

Recent abrupt cuts in United States scientific funding underscores just how damaging governmental shifts can be, especially if centralised. Hence rebuilding scientific capacity with more diverse nodes may prove resilient to both extreme crises like ASRS, and more societal challenges in maintaining science-policy capacity.

4. Preferred Future: High systemic policy capacity, high organisational policy capacity

In the preferred future, institutional expertise and social legitimacy align. Governments design and implement effective interventions, and societies provide the enabling environment for participation and trust. Vulnerable groups are not only recipients of aid but also partners in recovery. Food systems are rebuilt through inclusive agrarian policies. Inclusive agrarian policies ensure that smallholders and rural communities have equitable access to land, resources, and decision-making - for example, through land reform, secure tenure rights, and support for cooperative or small-scale farming. They also include measures like rural credit schemes, seed banks, and participatory governance to prevent elite capture and build resilience after shocks such as conflict or environmental disasters.This also allows displaced populations to be integrated through labour and housing programmes, and health systems provide robust, gender-sensitive care.

Vignette: *An elderly person with chronic illness, benefits from a community health initiative that integrates local caregiving networks with national resources. Food cooperatives led by smallholder farmers are supported by subsidies and international partnerships, while advocacy groups sit at the policymaking table. Society adopts a narrative of care and interdependence—"no one is left behind"—which sustains both trust and resilience.*

In the aftermath of nuclear war, resource depletion means only a limited amount of people can be saved.Communities oriented around mutualistic relations are probably going to do better than both those that don't triage at all and those that are overly harsh, selfish, and untrusting. However, no amount of community orientation or resilience building will match the absolute medium-long term devastation caused by a nuclear strike. Recommendations and solutions proposed in this report are likely only applicable at a localised level, as their applicability at a global or even regional level is largely unknown.

Systemically, this reflects high trust, legitimacy, and participatory governance. At the **worldview layer**, guiding metaphors emphasise care, dignity, and shared humanity.

Synthesis

The comparative analysis highlights how the futures of vulnerable groups depend less on the hazard itself than on the alignment of **policy capacity and legitimacy,** including the maintenance and functionality of social and public institutions after the nuclear strike. In the Harmful Future, absence of both leads to abandonment. In Alternative Future 1, technocratic capacity without societal trust produces contested or hollow policies. In Alternative Future 2, community resilience fills the gap but cannot compensate for structural fragility. Only in the Preferred Future do state expertise and social legitimacy combine to generate equitable recovery.

Inayatullah's CLA shows that these outcomes are underpinned by worldviews: fatalism and exclusion normalise abandonment; mistrust fragments otherwise well-designed policies; solidarity enables short-term adaptation but risks exhaustion; and inclusive metaphors foster durable resilience. Addressing these deeper cultural logics is as important as building institutional expertise. Without shifting narratives from exclusion and mistrust to interdependence and dignity, policy responses - even when technically sound - remain fragile (Scheidel, 2018).

Table 4: Comparative Table of Futures of Subjects after 2nd Order Nuclear Impacts

Future Type	Organisational Policy Capacity	Systemic Policy Capacity	Subject experience (vignette)	Systemic factors	Worldview factors	Implications
Harmful	Low	Low	A migrant worker, loses their job and remittance flows; abandoned by both state and community	Institutional breakdown; erosion of trust	Fatalism; exclusionary nationalism	Total neglect; vulnerable groups left to collapse
Alternative Future 1	High	Low	A smallholder farmer, joins a state seed programme but faces community distrust and isolation.	Technocratic capacity but weak legitimacy	Mistrust of state; policy as "top-down" imposition	Policies well-designed but socially contested; uneven uptake

Alternative Future 2	Low	High	A Pacific subsistence farmer, joins collective food-sharing; solidarity sustains short-term resilience, but health shocks overwhelm	Strong social cohesion; weak state institutions	Solidarity; reciprocity; “we recover together”	Resilience through community action; fragile and uneven outcomes
Preferred	High	High	An elderly widow, receives care from integrated community and state health programmes; no one left behind	Institutional strength; trust; participatory governance	Interdependence; dignity; shared humanity	Inclusive resilience; subjects empowered as co-agents

Horizon 3: Building Metrics for Long-Term Resilience

Analytical focus: Translating scenarios into monitoring tools, indicators, and pathways.

Workshop 4 – Stress Testing

Under each future, the relevant solutions were now stress tested, to assess their effectiveness in each scenario. These were stress tested against Resilience, as defined by Roberts (2023): Absorb, Adapt Transform:

Absorb - the ability of a society to absorb the threat and hazard of the 2nd order impacts of a nuclear strike

Adapt - the ability of society to respond to the threat or hazard of a nuclear strike by making adjustments that allow society to continue functioning.

Transform - moving from destruction to long-term resilience and recovery pathways, post nuclear strike.

Analysing vulnerable “subjects” through the resilience dimensions of **absorptive**, **adaptive**, and **transformative** capacity offers a view of how components of society might cope with the 2nd order impacts of a nuclear strike. These dimensions are deeply conditioned by the configuration of systemic and organisational policy capacities. While absorptive and adaptive capacities are immediate and short-term, transformative capacity requires reconfiguring governance, incentives, and infrastructures over the long term. Integrating proposed solutions—ranging from humanitarian logistics and food system redesign to regenerative agriculture and bioengineering—illustrates how feasible these resilience strategies might be in each future.

1. Harmful Future (Low organisational, low systemic capacity)

In the harmful future, societies are stripped of both institutional capacity and social legitimacy. Vulnerable subjects here struggle to **absorb** shocks as supply chains collapse, food scarcity spreads, and civil defence frameworks fail. Stockpiles are absent or inaccessible due broad governance dysfunctions, and humanitarian logistics preparedness is paralysed.

Adaptation is minimal: households or communities improvise survival mechanisms such as scavenging or informal barter, but there is little scope for structured adjustments. Alternative foods (e.g., seaweed diets) or bio-engineered crops remain out of reach due to lack of coordination and investment.

Transformation is effectively impossible. Without functioning governance, opportunities for regenerative transitions, resilient seed systems, or diversified supply networks are lost. This future epitomises Wisner et al.’s “unsafe conditions,” where vulnerability is reproduced by the absence of both root causes (inclusive governance) and dynamic pressures (preparedness systems).

2. Alternative Future 1 (High organisational, low systemic capacity)

Here, states maintain technical expertise but suffer from legitimacy deficits. The absorptive capacity of societies improves compared to the harmful future, but in socially uneven ways. Governments may successfully **preposition stockpiles** or establish transport route diversification plans, enabling targeted delivery of humanitarian aid. Yet, marginalised groups remain excluded due to mistrust or discrimination.

Adaptive capacity emerges in the form of top-down interventions: accelerated investment in bio-engineering of crops to enhance UV tolerance, controlled use of seaweed diets, and development of resilient seed systems. However, the lack of participatory governance weakens social uptake—for example, farmers mistrust official certification standards or migrants are excluded from rations

Transformative potential exists but is brittle. Technical innovations such as AI-enabled NC3 fail-safe protocols, or the establishment of food systems infrastructure standards, can theoretically reconfigure vulnerabilities. Yet without social legitimacy, these transformations reproduce asymmetries: food access, land rights, and health recovery frameworks remain skewed towards elites. Transformations occur “on paper” but deepen exclusion, echoing Turner et al.’s concern with the uneven distribution of resilience across coupled human–environment systems.

3. Alternative Future 2 (Low organisational, high systemic capacity)

In this quadrant, societies possess cohesion and solidarity but lack strong institutions. **Absorptive capacity** is enhanced through mutual aid and to an extent, localisation. Communities establish informal stockpiles, repurpose local transport routes, and rely on social infrastructure to provide shelter and food-sharing. Migrants may find refuge in community networks, while subsistence farmers pool resources to buffer shocks.

Adaptive strategies are driven from below: bioregional food governance structures and resilient food production knowledge commons are improvised through local leadership. Alternative foods (seaweed, novel proteins) may be adopted earlier where communities are open to experimentation, though uneven technical support limits widespread deployment.

Transformative capacity is constrained but latent. Community solidarity creates fertile ground for resilient seed systems and agricultural methods, but without organisational scaffolding, scaling up remains difficult. Nevertheless, social cohesion and bioregional governance can catalyse grassroots transformations, pointing to hybrid pathways where bottom-up resilience prefigures structural change once institutional support emerges. This future resonates with the *Pressure and Release* model’s emphasis on reducing unsafe conditions through social solidarity, even in the absence of formal structures.

4. Preferred Future (High organisational, high systemic capacity)

The preferred future aligns absorptive, adaptive, and transformative capacities. **Absorption** is facilitated by robust humanitarian logistics preparedness and prepositioned regional stockpiles, reducing immediate disruptions. Diversified global and national transport routes ensure that shocks to one hub do not paralyse supply chains. However, this absorption would happen at a very local level, and would be limited, particularly as the dependence of localities on global supply chains and certain transport infrastructures that are not easily duplicated or replaced is substantial. Vulnerable subjects can also engender resilience, such as migrants being covered by gender-sensitive civil defence, smallholder farmers being integrated into distribution networks, and elderly groups accessing reliable health infrastructure.

Adaptive capacity is systematically developed. Bio-engineering of UV-resistant crops and preparations for large-scale seaweed diets are combined with reductions in food waste and animal feed, extending limited food resources. Integrated food systems data infrastructure enhances responsiveness by providing real-time monitoring of shortages and surpluses. Local self-sufficiency is supported without retreating into isolationism, thanks to decentralised but interconnected global networks.

Transformative capacity (being resilience & recovery) is unlocked as societies find pathways to implement long-term resilience and recovery of critical food, energy and governance systems—even if the end-state of resilience and recovery is below the pre-strike 'baseline.' Given the extensive 2nd order effects of a nuclear strike, transformation entails finding a new equilibrium for survival in a fundamentally changed world, and not necessarily pursuing the same quality of life to the pre-strike society. Agroecological regenerative agriculture transitions are accelerated through international certification standards and resilient seed systems. Bioregional food governance and resilient knowledge commons ensure bottom-up legitimacy, while polar class vessels and diversified supply chains secure global redundancy. Safeguards embedded in AI-enabled NC3 systems reduce systemic risks of miscalculation. The worldview underpinning this future is one of interdependence, allowing vulnerable subjects to survive together and co-shape a long-term future after a nuclear strike.

Comparative Insights

Across futures, **absorptive capacity** is weakest where institutional and social capital are simultaneously absent, but it can be shored up by either organisational expertise (Alternative Future 1) or systemic solidarity (Alternative Future 2). **Adaptive capacity** requires coordination of knowledge, resources, and legitimacy; thus, it is underdeveloped in harmful futures, partial in alternatives, and optimal only in the preferred case. By contrast, **transformative capacity** towards resilience and recovery, depends most on the alignment of organisational and systemic strengths: without both, either technocratic exclusion (Alternative Future 1) or fragmented grassroots initiatives (Alternative Future 2) prevail.

The proposed solutions demonstrate varying degrees of feasibility across futures. Logistics preparedness, stockpiling, and diversification strategies are most effective for **absorptive resilience**, while alternative foods, bioengineering, and local self-sufficiency enhance **adaptive capacity**. **Transformative resilience** relies on agroecological transitions, bioregional governance, and integrated infrastructures—possible only where institutional expertise converges with societal legitimacy.

Workshop 5 – Backcasting

As a final exercise, participants developed Blue Sky backcasting (critical milestones for preferred futures) against the factors of resilience (Roberts, 2023).

A synthesis of common themes across backcasting is as follows:

Table 5: Synthesis of common themes across backcasting against factors of resilience

Resilience Dimension	**Key Features/Challenges**	**Required Steps/Interventions**
Absorb	Fully functioning governance and cohesive society; aim is to withstand immediate shocks without systemic collapse	- Maintain **robust global and regional stockpiles** - Implement **global transport network diversification** to prevent bottlenecks - Embed **integrated logistics data systems** for real-time resource tracking - Ensure **equitable access** via inclusive civil defence and recovery framework - Strengthen **local social infrastructure** to buffer shocks
Adapt	Ability to adjust food, energy, and recovery systems in response to prolonged stress	- Coordinate **bio-engineered UV-resistant crops** and **seaweed diets**- Reduce **food waste** and divert surplus from animal feed

		- Establish **integrated food systems data infrastructure** for monitoring shortages/surpluses - Expand **resilient seed systems**, **knowledge commons**, and local self-sufficiency programs - Balance **global and local production** via decentralised networks
Transform	Long-term restructuring of socio-ecological and governance systems to reduce vulnerability and facilitate resilience & recovery.	- Fully implement **agroecological regenerative agriculture transition acceleration** - Establish **international certification standards** for resilient food systems infrastructure - Combine **bioregional governance, knowledge commons, and integrated infrastructures** for participatory legitimacy - Embed **AI-enabled fail-safe protocols** and **polar-class vessel networks** for systemic redundancy - Promote a worldview of **interdependence and shared dignity**, enabling vulnerable populations to co-shape transformation

In summary:

1. **Absorption**: Requires immediate access to supplies, logistics, and redundancy.

2. **Adaptation**: Depends on coordination of knowledge, resources, and legitimacy; feasible if either institutional expertise or social cohesion exists.

3. **Transformation**: Needs both organisational strength and systemic legitimacy; absent either, attempts either reinforce inequities or remain fragmented.

4. **Sequencing**: Absorption → Adaptation → Transformation; interventions build cumulatively, and early investment in absorption and adaptation lays the groundwork for longer-term resilience and recovery.

Conclusion

The Horizon Summit brought together eight experts to explore the cascading 2nd order impacts of a nuclear detonation, revealing a complex web of vulnerabilities and interdependencies across governance, food systems, infrastructure, health, and social cohesion. Each scenario—ranging from the collapse of multilateral arms control regimes to the resurgence of sea ice, the erosion of local knowledge systems, and the destabilising effects of AI in nuclear command systems—underscores the inadequacy of conventional crisis response frameworks when facing systemic, long-duration disruptions.

The focus of this exercise as with general horizon scanning is to identify novel or emerging insights. As such some may be particularly inventive, and have extra utility for stretching collective thinking around resilience measures beyond what might otherwise be deemed obvious or banal.

The findings highlight that addressing 2nd order impacts requires more than reactive crisis governance, which is compounded by historical vulnerabilities that must be addressed (**H1**). It demands systemic interrogation of the preferred, alternative, and harmful futures (**H2**), which includes robust and transparent monitoring systems,such as integrated food systems data infrastructures and AI fail-safe protocols—to ensure decision-makers are equipped with timely, accurate, and context-sensitive information.

Equally critical is the development of transformative change potentials, of a potentially future paradigmatic nature to build sustainable and equitable resilience and recovery (**H3**). These could include the decentralisation of food production through regenerative agriculture, the embedding of gender-sensitive and culturally inclusive recovery

frameworks, and the redesign of infrastructure to withstand abrupt environmental reversals.

The Summit further demonstrated that resilience is not solely a technical challenge but a deeply social one. Solutions such as strengthening local social infrastructure, preserving Indigenous knowledge systems, and establishing bioregional governance frameworks demonstrate that trust, equity, and cultural continuity are foundational to long-term recovery. Without these, societies risk fragmentation, extremism, and the erosion of international cooperation—outcomes that would only deepen the crisis. Furthermore, many of these knowledge bases (perhaps seeing the ecology as an ancient distributed intelligence, and indigenous groups as often managing and reversing such worldviews) have already stood the test of time, but suffered due to modern developmental and political priorities.

Ultimately, the Horizon Summit demonstrates the value of deliberative, multi-method foresight in navigating the long-term consequences of nuclear crises. By integrating diverse knowledge systems, anticipating compounding risks, and designing for adaptability, such exercises can generate actionable pathways for resilience. In a world increasingly shaped by systemic shocks, this approach offers a blueprint not only for surviving catastrophe, but for promoting pathways for long-term resilience and recovery that are applicable also for other disruption scenarios that are less extreme than nuclear strikes, such as natural disasters or conventional warfare.

The authors wish to restate a strong opposition to any use of nuclear weapons, or indeed drawing any foolhardy assumptions about future civilisational health or quality of living after such a cataclysm. While scanning the abyss may imply it can be ‘governed’ with more ease than without, the scale and permanence of any such outcome necessitates extreme caution in outlining lessons around it. None of this would be easy, and all of the need for it to be avoided by any means necessary.

Next Steps for Policymakers

1. **Mandate interdepartmental scenario exercises** within the next 12 months to stress test national systems against cascading nuclear impacts, including food, energy and health dependencies. These exercises should go beyond traditional tabletop drills by involving regional authorities, critical-infrastructure operators and community groups to capture real-world interdependencies. They should also generate a set of cross-agency “red team” findings to feed directly into future contingency planning.

2. **Establish a cross-government taskforce on 2nd order impacts** of nuclear conflict to coordinate preparedness, recovery planning and integration of

foresight. This body should report to Cabinet or National Security Council level, with clear authority to direct budgets and set standards across departments. Embedding liaison officers from civil society and private sector networks can ensure the taskforce benefits from wider expertise.

3. **Develop a national stockpile and pre-positioning strategy** for critical supplies in partnership with local authorities, private sector and community organisations. This strategy should map vulnerable supply chains and identify optimal regional storage sites to minimise transport bottlenecks. Transparent rotation of supplies and public communication plans will increase public trust and reduce waste.

4. **Pilot resilient food production initiatives** – such as controlled-environment agriculture, resilient seed banks and seaweed-based nutrition – in at least three high-risk regions. These pilots should be designed as living laboratories that generate operational lessons for national roll-out. International partners can be invited to co-invest, allowing knowledge sharing and joint certification of standards.

5. **Create a public–private data infrastructure** to integrate supply chain, health and transport information in real time during crises. This platform should combine government datasets with industry and civil society contributions under clear privacy and security protocols. A joint governance model will help ensure that during a nuclear-related disruption, decision makers can quickly identify chokepoints and mobilise alternative routes or suppliers.

6. **Update continuity-of-government legislation** to ensure clear lines of authority, protection of democratic norms, and inclusion of gender-sensitive frameworks in post-strike governance. This should include predefined triggers for emergency powers and sunset clauses for their withdrawal to maintain legitimacy. Training programmes for officials and local leaders will build familiarity with these provisions before a crisis hits.

7. **Launch an international working group** with allies and multilateral organisations to set certification standards for food systems infrastructure and recovery. By creating common benchmarks, states can speed up mutual assistance agreements and ensure that emergency food trade flows smoothly even when normal market mechanisms fail. Participation of low- and middle-income countries will help to embed equity from the outset.

8. **Commission an independent review** of AI integration in nuclear command and control to ensure safeguards and fail-safe protocols are in place before adoption. This review should examine not only technical vulnerabilities but also legal and ethical implications of delegating decisions to AI systems. Recommendations should be published publicly where possible to build confidence among allies and domestic populations.

9. **Embed intergenerational fairness metrics** into all major resilience and security policies, with annual public reporting to strengthen legitimacy and accountability. Metrics could track, for example, the long-term distributional effects of preparedness spending, or the inclusiveness of recovery planning. Publishing these metrics will help anchor resilience policy in a transparent, future-oriented frame rather than short-term crisis management.

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