Global Resilient Anticipatory Infrastructure Network (GRAIN)

Overview Report

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1 EXECUTIVE SUMMARY

This report presents the strategic insights and outcomes of the Global Resilient Anticipatory Infrastructure Network (GRAIN), an initiative of the Odyssean Institute designed to support transformative resilience across critical global systems. In a time of escalating global risks—ranging from climate disruption and technological fragility to economic instability and institutional decay—GRAIN offers a practical, interdisciplinary roadmap for governments, researchers, and industries seeking to shift from reactive crisis management to proactive, adaptive governance.

The report directly addresses six urgent questions concerning the nature of information, cognitive, and social adaptability; barriers to action; resilience trade-offs; policy (in)capacity; and the importance of strategic nodes in global recovery. Through this lens, it redefines resilience not as a return to the status quo, but as a foundation for antifragility—a system's capacity to grow stronger through volatility and disruption.

Drawing on Mariana Mazzucato's mission-oriented policy framework, the report proposes a shift in how policymakers approach long-term planning and uncertainty. Rather than narrowly focusing on sectoral optimisation or risk minimisation, mission-oriented strategies offer a unifying structure for developing Shared Socio-economic Pathways (SSPs) that harmonise economic innovation, climate neutrality, and social wellbeing. Ambitious, clearly defined missions—such as climate-resilient agriculture or decarbonised industrial competitiveness—provide a basis for aligning public, private, and civic actors around system-wide transformation.

GRAIN operationalises these missions through a staged process. First, it convenes diverse experts for targeted foresight activities that identify emerging risks, systemic bottlenecks, and pathways to resilience. This process surfaces both short-term incentives and long-term trajectories for adaptive capacity. Next, it applies scenario-based exploration to map trade-offs, exposures, and latent advantages in key systems, enabling stakeholders to co-create tailored interventions that reinforce competitiveness while enhancing global resilience.

The report advances this strategic approach through a suite of futures methodologies:

- **Causal Layered Analysis (CLA)** to interrogate surface trends, systemic causes, worldviews, and metaphors underlying complex phenomena;
- **The Futures Triangle** to analyse the 'pulls' of preferred futures, 'pushes' of the present, and 'weights' of history that constrain transformation;
- **Scenario Mapping** to generate and stress-test alternative futures in domains of uncertainty, from geopolitics to infrastructure.

These are complemented by three integrative frameworks:

- **Bill Sharpe's Three Horizons framework** , which helps actors navigate system transformation by distinguishing between current dominant patterns (Horizon 1), emerging innovations (Horizon 2), and visionary, long-term futures (Horizon 3);
- **Seth Baum's Civilisational Trajectories**, which situate policy choices within broader evolutionary pathways for humanity—ranging from collapse and stagnation to transformation and flourishing.

By layering these approaches, the report creates a structured, participatory process through which interventions can be tested, adapted, and scaled. It also builds a bridge between near-term policy cycles and long-term systemic evolution.

The report also introduces a novel diagnostic approach to global resilience. Using Revealed Comparative Advantage (RCA)—a tool typically applied in trade economics—it identifies countries or regions with disproportionate capabilities in sustaining complexity, innovation, or recovery. These are termed 'nodes of persisting complexity' (e.g., jurisdictions with exceptional innovation systems, institutional coherence, or advanced infrastructure) and 'nodes of persisting recovery' (e.g., hubs critical to restarting global trade, logistics, or agricultural production after crisis).

These nodes are not simply passive assets but potential leverage points for a more distributed, polycentric approach to resilience. The report recommends prioritising diplomatic, scientific, and infrastructural partnerships with these actors to reinforce systemic stability at the global level.

A key insight of the report is that policy incapacity—manifesting in fragmented governance, poor knowledge integration, and short-termism—is itself a driver of systemic vulnerability. Accordingly, the report offers a diagnostic model for assessing institutional readiness, based on the presence or absence of epistemic integrity, cross-sectoral coordination, and participatory governance.

Interventions identified through the GRAIN process can then be structured as mission-oriented public policy, with measurable goals, distributed ownership, and adaptive governance. Outcomes may include improved anticipatory capacity, greater social trust, stronger regional autonomy, and deeper integration of wellbeing into economic and infrastructural decisions.

Finally, GRAIN is designed not as a fixed blueprint, but as a living process—one that can be iterated in diverse localities, adapted to cultural and institutional contexts, and refined over time. Through academic dissemination, communities of practice, and international cooperation, the GRAIN methodology supports the diffusion of best practice and the development of globally informed, locally anchored resilience strategies.

In sum, the report calls for a decisive shift in global governance—from fragmented crisis response to anticipatory, inclusive, and mission-driven policy. By aligning foresight with action, and complexity with clarity, GRAIN offers a pragmatic yet ambitious template for making societies not only safer, but stronger through disruption.

2 PREAMBLE

Uncertainty is the tenor of our times. The world is wrestling with the so-called 'polycrisis' across socio-political, technological, environmental, and economic domains.[1] Patricia Lustig and Gill Ringland argue we exist in an era of 'backbones' becoming fractured - with 'backbones' being the implicit norms, values, and worldviews, along with the explicit institutions, laws, and economic practices, that we assumed were constants underpinning our social and political fabric.[2] These implicit assumptions have promoted a lack of foresight, and instilled a level of denial and complacency. We need far more than technocratic approaches to deal with such uncertainty - we need to address how we collectively ideate resilience of the essential systems we depend upon for survival, with a long-term, systemic worldview.

By using strategic foresight methodologies, and mission-oriented frameworks for the key sectors in the economy, we can systematically explore, anticipate, and shape futures for the wellbeing and resilience of society. Complementing this, through pragmatic analyses of the locations, lynchpins, and crucial flows of commodities, we can chart a course to stronger resilience and flourishing.

The Global Resilient Anticipatory Infrastructure Network (GRAIN) is how the Odyssean Institute develops proposals for local, regional, and global action towards enabling long-term resilience. It combines strategic foresight methodologies, frameworks of resilience and mission-oriented policymaking, to generate wellbeing and resilience for the long-term. In doing so, it offers a broad and deep set of frameworks to address complexity in a pragmatic, coherent, and well-evidenced manner.

3 INTRODUCTION

GRAIN's approach provides a way of producing quality research with actionable strategies to enhance resilience across investment, trade, or scientific initiatives, directed at:

- Civil service and contingency planning departments
- Trade departments and industrial policymakers
- Private companies with strategic positions in relevant sectors
- Incubators or startups working to advance R&D testing and scaling in these areas

GRAIN seeks to identify crucial components of our complex civilisation, and to build adaptive capacity for their maintenance and growth. These include both materialistic (i.e. food and

[1] Toby Ord. *The Precipice: Existential Risk and the Future of Humanity*. eng. OCLC: 1164504666. S.l.: Hachette Books, 2021. ISBN: 978-0-316-48492-3.

[2] Patricia Lustig and Gill Ringland. *The possibility wheel: making better choices in a fractured world*. eng. First edition. OCLC: 1467877721. Axminster, England: Triarchy Press, 2024. ISBN: 978-1-917251-06-8.

critical industries) and non-materialistic components, such as social trust, cohesion, and the generation of wellbeing amongst the public through institutional resilience and mission-driven expertise. The inability to enable and reinforce these categories lead to a significant curtailment of humanity's resilience, flourishing, and risk locking us into long term vulnerability.

The manifestation of Global Catastrophic Risks (GCRs)[3] will mean materialist and non-materialist dimensions across informational, cognitive-affective, and infrastructural domains, will be essential for societal resilience, recovery, and adaptation. Likewise, these materialist and non-materialist components of resilience are important in mitigating the worst impacts of long term stress that erode the stability and cohesion of society. These stresses include the decay of social trust & cohesion, declining trust in government, the impacts of climate change, economic stagnation, and fragile supply chains.[4]

The initiative also aims to address unfolding system degrading catastrophes such as the current climate and ecological crises. For example, in less extreme scenarios such as a limited collapse of regional infrastructure, how can higher tech, their precursor and modular components, and governance solutions proactively be developed to reduce the worst consequences and preserve our quality of life. How can the multitude of solutions satisfy various dimensions of our current civilisational complexity with respect to materialistic, subjective, and collective wellbeing for as many as possible? Complementing this, non-materialist resilience, based around social cohesion and trust of institutions, facilitates the success or failure of materialist resilience, as the effective governance of materialist resilience depends on effective institutions and social cohesion.

GRAIN is a standalone project but also a focus for the Odyssean Process.[5] By deploying more advanced decision making processes onto complex and wicked problems, a collective framing of policies can be undertaken, clarifying sophisticated issues through multiple diverse perspectives. Through participation and exploratory modelling, the Odyssean Process can then help to identify effective strategies with sustainable support.

This might take the form of running the process in a specific location (e.g. the trading chokepoint of Panama Canal), and on specific trade qualities and quantities (e.g. how many resilient foods flow, or can flow, through that trade chokepoint, in various catastrophic scenarios which may result in their disruption). This will then aim to ensure our research and practice efforts can cross-pollinate, bringing expertise, local knowledge, and global science to bear on ensuring the continued flow of such essential components of global adaptive capacity. GRAIN might

[3] Simon Beard and Phil Torres. *Identifying and Assessing the Drivers of Global Catastrophic Risk*. Tech. rep. Global Challenges Foundation, 2019. URL: https://globalchallenges.org/library/identifying-and-assessing-the-drivers-of-global-catastrophic-risk-2019/.

[4] Giuseppe Dal Prá et al. *A Horizon Scan of Global Catastrophic Risks*. Aug. 2024. DOI: 10.13140/RG.2.2.24382.91205/2.

[5] Giuseppe Dal Prá, B. Ashgar, and Christopher Chan. *The Odyssean Process: An Innovative Approach to Decision Making for an Uncertain Future*. Tech. rep. The Odyssean Institute, 2023. URL: https://www.odysseaninstitute.org/_files/ugd/e56281_f0a77ff859354023bf743d07b9cea519.pdf.

also benefit from assessing to what extent social trust, or trust between society and institutions, enables or disables resilience in these types of circumstances.

GRAIN also uses Revealed Comparative Advantage (RCA)[6] as an analytical tool to build a typology of countries that accompany and extend existing nodes of persisting complexity.[7] This assesses the unique comparative advantages of countries and their productive and trade capacities of bundles of goods. In doing so, it quantitatively compares comparative advantages of particular jurisdictions in the trading of critical commodities. We developed an index to capture these nodes of persisting complexity in terms of bread baskets, higher tech, resilience capacities, and other restorative interventions. This is particularly important for less resilient states, such as Small Island Developing States (SIDS), who are on the forefront of global shocks and stresses.[8]

Resilience is a deeply polysemic and contested concept, requiring a transdisciplinary, systems-thinking approach that spans multiple policy domains.[9] The various interpretations of resilience—from ecological and technological to social and institutional—demonstrate its complexity and the necessity of integrating diverse perspectives. Scholars such as Seth Baum,[10] Igor Linkov,[11] and Lewis Dartnell[12] offer overlapping yet distinct views on resilience, emphasising everything from catastrophe trajectories to cognitive resilience and the restoration of productive capacities. A comprehensive understanding of resilience, therefore, demands an appreciation of these varied contributions.

We also want to assess the risks of trade exposure, in the event of major shocks or stresses, but also how Revealed Comparative Advantage (RCA) can enable global 'nodes' to be pillars of resilience and recovery during global shocks and stresses.

[6] Scott French. "Revealed comparative advantage: What is it good for?" en. In: *Journal of International Economics* 106 (May 2017), pp. 83–103. ISSN: 00221996. DOI: 10.1016/j.jinteco.2017.02.002. URL: https://linkinghub.elsevier.com/retrieve/pii/S0022199617300247 (visited on 06/05/2025).

[7] Nick King and Aled Jones. "An Analysis of the Potential for the Formation of 'Nodes of Persisting Complexity'". en. In: *Sustainability* 13.15 (July 2021), p. 8161. ISSN: 2071-1050. DOI: 10.3390/su13158161. URL: https://www.mdpi.com/2071-1050/13/15/8161 (visited on 06/05/2025).

[8] The Odyssean Institute. *Pathways to Resilience: Learning from the Small Island States Resilience Initiative*. Tech. rep. The Odyssean Institute, 2024. URL: https://www.odysseaninstitute.org/post/pathways-to-resilience-learning-from-the-small-island-states-resilience-initiative.

[9] Peter Rogers. "Researching resilience: An agenda for change". en. In: *Resilience* 3.1 (Jan. 2015), pp. 55–71. ISSN: 2169-3293, 2169-3307. DOI: 10.1080/21693293.2014.988914. URL: http://www.tandfonline.com/doi/abs/10.1080/21693293.2014.988914 (visited on 06/05/2025).

[10] Seth D. Baum et al. "Long-term trajectories of human civilization". en. In: *foresight* 21.1 (Mar. 2019), pp. 53–83. ISSN: 1463-6689. DOI: 10.1108/FS-04-2018-0037. URL: https://www.emerald.com/insight/content/doi/10.1108/FS-04-2018-0037/full/html (visited on 06/05/2025).

[11] Igor Linkov et al. "Measurable Resilience for Actionable Policy". en. In: *Environmental Science & Technology* (Sept. 2013), p. 130903081548008. ISSN: 0013-936X, 1520-5851. DOI: 10.1021/es403443n. URL: https://pubs.acs.org/doi/abs/10.1021/es403443n (visited on 06/05/2025).

[12] Lewis Dartnell. *How to rebuild the world from scratch | Lewis Dartnell*. Nov. 2016. URL: https://www.youtube.com/watch?v=CdTzsbqQyhY (visited on 11/06/2024).

Building resilience requires strong policy capacity, particularly a blend of organisational and systemic policy capacity.[13] Governments alone cannot achieve resilience; rather, bridging across government, civil society, and business stakeholders is essential to ensure effective responses to shocks and stresses.[14] This aligns with the mission-oriented governance framework of Mariana Mazzucato,[15] which structures efforts to address grand challenges by integrating multiple sectors and actors under shared goals—coordinated by the government using all the tools at its disposal. By adopting mission-oriented policies, societies can navigate complexity while maintaining coherence in resilience-building efforts.

Moreover, resilience is both a materialist and non-materialist concept. Materialist aspects focus on tangible elements such as infrastructure, food supply chains, and resource security, while non-materialist aspects emphasise institutional resilience, governance frameworks, and adaptive capacities. For example, a mission for food sovereignty and security ensures supply-chain resilience by shifting from purely just-in-time models to more robust just-in-case systems. Strengthening and multiplying supply chains in this way enhances food security and reduces vulnerabilities to external shocks.

Ultimately, resilience is not a static state but a dynamic, evolving capacity that must be continuously reinforced through coordinated, forward-thinking policymaking. By integrating diverse perspectives, fostering cross-sector collaboration, and adopting mission-driven strategies, societies can enhance their ability to withstand and adapt to future challenges.

3.1 RESEARCH OBJECTIVES

This report provides an overview of a broad range of frameworks and principles that GRAIN draws on in its approach to informing policy actors of avenues for enabling resilience and well-being in their jurisdictions. Achieving this will enable wicked problems, complexity and uncertainty to be interrogated and overcome in policymaking circumstances.

The research in this report aims to assess the distributional resilience of material and non-materialist resilience across numerous domains—referring to the spread or concentration of resilience among demographics, sectors, and stakeholders. The contemporary world is demonstrating major and sudden shifts in political, economic, environmental, and technological land-

[13] X Wu, M Ramesh, and M Howlett. "Policy capacity: A conceptual framework for understanding policy competences and capabilities". en. In: *Policy and Society* 34.3-4 (Sept. 2015), pp. 165–171. ISSN: 1449-4035, 1839-3373. DOI: 10.1016/j.polsoc.2015.09.001. URL: https://academic.oup.com/policyandsociety/article/34/3-4/165/6401373 (visited on 06/09/2025).

[14] Michael Howlett and M. Ramesh. "Achilles' heels of governance: Critical capacity deficits and their role in governance failures". en. In: *Regulation & Governance* 10.4 (Dec. 2016), pp. 301–313. ISSN: 1748-5983, 1748-5991. DOI: 10.1111/rego.12091. URL: https://onlinelibrary.wiley.com/doi/10.1111/rego.12091 (visited on 06/05/2025).

[15] Mariana Mazzucato and George Dibb. *Missions: A beginner's guide*. Tech. rep. IIPP PB 09. UCL Institute for Innovation and Public Purpose, 2019. URL: https://www.ucl.ac.uk/bartlett/sites/bartlett/files/iipp_policy_brief_09_missions_a_beginners_guide.pdf.

scapes, with these landscapes increasingly interfacing with each other.

For example, COVID-19 demonstrated the vulnerability of global supply chains. Additionally, President Trump's tariffs have prompted deindustrialised economies to reshore and invest in domestic manufacturing. Likewise, the adverse and tumultuous economic circumstances the world continues to experience, and has commonly experienced since the 2008 Global Financial Crisis (GFC), has disrupted the globalised economic consensus that dominated global economic decision making from the 1980s until the early 2020s,[16] where COVID-19 and recovery from it necessitated governments to play an active role in enabling social and economic resilience.[17]

3.2 RESEARCH QUESTIONS

The GRAIN initiative seeks to answer the following questions, of which this report is the starting point:

1. What short, medium, and long-term changes are needed to achieve better informational, cognitive, and social adaptability and antifragility across the various stages of resilience (absorb, recover and adapt)?

2. What are the drivers of inaction preventing these stages of resilience, especially across informational, cognitive, and social domains?

3. What trade-offs are there in enhancing resilience in particular policy areas?

4. How can we aim for adaptive capacity going beyond current systemic fragilities, or 'antifragility'—growing stronger from uncertainty?

5. To what extent does policy (in)capacity enhance or undermine resilience?

6. How important is creating nodes of persisting complexity and nodes of persisting recovery? How can they enable long-term resilience of global trade stocks and flows in the event of global catastrophic risks?

7. What concrete processes can be simulated or envisioned for recovery of agriculture, industry, and science, answered with reference to case study countries and sectors?

[16] Franklin Foer. "The New Washington Consensus". In: *The Atlantic* (Sept. 2023). URL: https://www.theatlantic.com/ideas/archive/2023/05/biden-economics-industrial-policy-trump-nationalism/673988/.

[17] Usman W Chohan. "The return of Keynesianism? Exploring path dependency and ideational change in post-covid fiscal policy". en. In: *Policy and Society* 41.1 (Jan. 2022), pp. 68–82. ISSN: 1449-4035, 1839-3373. DOI: 10.1093/polsoc/puab013. URL: https://academic.oup.com/policyandsociety/article/41/1/68/6513363 (visited on 06/05/2025).

3.3 RESEARCH METHODS

The GRAIN initiative applies a broadly mixed methods research approach, chosen to collate the disparate research fields needed to address the above questions. These methods include a mix of quantitative, including econometrics, and qualitative research methods, including but not limited to:

- Root Cause Analysis (qualitative)
- Processing tracing (qualitative)
- Structured expert interviews (qualitative)
- Horizon Scan (qualitative)
- Revealed Comparative Analysis (RCA) (quantitative)
- Computable General Equilibrium (CGE) and Dynamic Stochastic General Equilibrium (DSGE) (quantitative)

The report also focuses on existing frameworks that have bearing on large scale resilience, such as:

- **The resilience matrix of Igor Linkov**[18]—a multi-factor model of the dimensions of resilience, through which actors can plan, absorb, recover, and adapt.
- **The three horizons framework for enabling transformative change by Bill Sharpe**[19]—which helps us understand how to balance near term tactical interventions of more current concerns, with longer term more strategic transformations needed to maintain current living standards, or improve them, through the lens of long-term resilience.
- **Trajectories of civilisation from Seth Baum**[20]—a more sectoral approach that identifies the primary production of food, secondary of industry, and subsequently their interplay in conditions of catastrophe to recover more quickly from possible collapses.

These frameworks furnish a processual look at how to balance differing time horizons and preferences, allowing the eventual use of decision aiding through decision making under deep uncertainty (DMDU)—an umbrella concept with a focus on helping decision makers identify and evaluate robust and adaptive strategies under environments of uncertainty. This is in addition to participatory methods for collective intelligence, to be more capable of dissolving deadlock

[18] Linkov et al., "Measurable Resilience for Actionable Policy".

[19] Bill Sharpe et al. "Three horizons: a pathways practice for transformation". en. In: *Ecology and Society* 21.2 (2016), art47. ISSN: 1708-3087. DOI: 10.5751/ES-08388-210247. URL: http://www.ecologyandsociety.org/vol21/iss2/art47/ (visited on 06/05/2025).

[20] Baum et al., "Long-term trajectories of human civilization".

and polarisation, in order to properly seize the necessary opportunities for pragmatic action without losing any boldness required for long term success.

Finally, we demonstrate how these frameworks of resilience can actually be implemented through Mariana Mazzucato's conception of 'mission-oriented policy'.[21]

By synthesising these approaches, GRAIN is able to inform a holistic appreciation of resilience.

4 APPLICATION OF THIS REPORT'S CONTENT FOR BUSINESSES, GOVERNMENT & RESEARCHERS

The GRAIN Overview Report presents a sophisticated, integrative framework that is highly pertinent for decision-making in both policymaking and business contexts, especially in the face of escalating global complexity and uncertainty. In an era characterised by so-called 'polycrisis'—overlapping challenges across the environmental, economic, social, and geopolitical spheres—GRAIN offers a multidimensional approach to resilience, grounded in systems thinking, strategic foresight, and mission-oriented policy design.

At its heart, GRAIN seeks to address what the authors describe as the breakdown of societal 'backbones'[22]—the implicit norms, institutions, and infrastructures that previously underpinned collective stability. It does so by offering tools and frameworks for understanding, planning, and acting across time horizons and domains. These are of critical value to both policymakers and business leaders seeking to navigate not only acute disruptions, but also chronic stressors that threaten the long-term viability of society and the economy.

4.1 RELEVANCE FOR POLICYMAKERS & GOVERNMENT

For government actors and civil service leaders, GRAIN provides a vital reframing of resilience. Rather than focusing solely on recovery after disruption, the report calls for anticipatory, systemic, and inclusive forms of governance capable of absorbing, adapting to, and transforming in response to uncertainty. This is exemplified through its application of the *Linkov Resilience Matrix*,[23] which maps resilience across four domains—physical, informational, cognitive, and social—against four stages: preparation, absorption, recovery, and adaptation. Policymakers can use this matrix to conduct gap analyses of national or sectoral preparedness, design cross-sector strategies, and align institutional responsibilities with resilience functions.

Equally important is the *Three Horizons Framework*,[24] which encourages decision-makers to

[21] Mariana Mazzucato. *Mission economy: a moonshot guide to changing capitalism*. eng. London: Allen Lane, an imprint of Penguin Books, 2021. ISBN: 978-0-241-41973-1 978-0-241-43531-1.

[22] Lustig and Ringland, *The possibility wheel*.

[23] Linkov et al., "Measurable Resilience for Actionable Policy".

[24] Sharpe et al., "Three horizons".

simultaneously manage the short-term operational horizon (H1), mid-term transitional innovations (H2), and long-term transformative visions (H3). This offers a powerful antidote to the 'presentism' that often dominates public policy, constrained by electoral cycles and immediate crises. By engaging with the Three Horizons approach, policymakers can better steward investments, regulations and public engagement processes that balance urgent action with the need for structural change.

A further contribution of GRAIN lies in its application of *Revealed Comparative Advantage* (RCA)[25] to resilience. This economic analysis tool, commonly used to evaluate trade specialisations, is redeployed here to assess which countries or regions hold strategic advantages in resilience-critical commodities—such as seaweed, liquefied natural gas (LNG), or semiconductors. This enables governments to identify nodes of 'persisting complexity' or 'persisting recovery'—geographies that will play outsized roles in supporting societal continuity during and after major disruptions, and in spreading what is needed for recovery after, respectively. Such data is invaluable for strategic investment, contingency planning, and regional cooperation.

GRAIN also directly addresses policy (in)capacity as a barrier to long-term resilience. Drawing on frameworks that assess analytical, operational, and political capacities at the individual, organisational, and systemic levels, the report highlights how a lack of epistemic robustness, institutional trust and civic participation can undermine the implementation of even the most well-designed resilience strategies. This attention to non-materialist dimensions—such as social cohesion, evidence-based decision-making, and participatory governance—broadens the conversation beyond material infrastructure and into the social and cognitive scaffolding upon which resilience ultimately depends.

4.2 APPLICATIONS FOR BUSINESS STRATEGY

Private sector leaders will find in GRAIN a robust framework for navigating complexity in an increasingly fragile global operating environment. For sectors such as energy, food systems, logistics, insurance, and advanced manufacturing, the report's emphasis on material and non-material resilience directly corresponds with contemporary ESG (Environmental, Social, and Governance) imperatives.

The RCA methodology, for instance, allows firms to better assess supply chain vulnerabilities and identify strategic supplier relationships in countries with high resilience potential. Understanding which geographies are likely to serve as hubs of trade continuity in crisis scenarios (e.g. Singapore in seaweed or Ireland in iron and steel) can inform risk mitigation strategies, diversification of procurement, and even the location of future investments or facilities.

GRAIN also suggests that businesses can benefit from greater involvement in public resilience efforts—through mechanisms such as co-financing infrastructure upgrades, participat-

[25] French, "Revealed comparative advantage".

ing in anticipatory policy design, or developing mission-aligned innovations in food security or energy efficiency. The report's attention to 'mission-oriented' frameworks, inspired by Mariana Mazzucato's work, aligns well with emerging models of corporate citizenship that see business not merely as a market actor, but as a co-architect of systemic solutions.

Furthermore, by foregrounding non-materialist resilience - such as institutional trust and social legitimacy—GRAIN reminds business leaders that reputation, transparency, and stakeholder relationships are central to long-term operational viability. In environments of polarisation and contested authority, firms that contribute to social cohesion and trust are more likely to be seen as credible and enduring actors.[26]

Ultimately, the *GRAIN Overview Report* provides a comprehensive and versatile set of tools for engaging with uncertainty at scale. For policymakers, it offers frameworks for cross-sectoral coordination, long-term planning, and participatory governance. For business leaders, it provides analytical techniques and strategic principles for navigating risk, supporting innovation, and aligning profit with purpose.

By integrating strategic foresight, systems thinking, and practical economic modelling, GRAIN equips decision-makers to move beyond fragmented responses toward coherent and anticipatory action. In doing so, it supports the shift from reactive resilience to proactive and regenerative approaches to societal flourishing—an essential shift if we are to address the complex challenges of the 21st century with any measure of success.

4.3 APPLICATIONS FOR RESEARCH

GRAIN also provides frameworks that enable researchers to cohere and analyse complex issues of wellbeing and resilience. This includes several frameworks of resilience, such as Linkov's Resilience Matrix, but also scenario mapping and mission-oriented policymaking frameworks from Mariana Mazzucato. By applying these frameworks to complex challenges, it allows researchers to answer the following questions with greater ease:

- Which areas of resilience in a system do we need to develop further?
- How do we develop clear 'missions' towards which we direct our resilience efforts?
- How do we anticipate and dissect multiple futures through which resilience and wellbeing can be enabled?
- What drivers enable long-term resilience, but also what are the typologies of inaction that exacerbate poor resilience and wellbeing outcomes?

This is complemented by an in-depth understanding of RCA, which helps business and economics researchers glean the global nodes of persisting complexity and recovery, focusing less

[26] Ruth Lawrence. *Social Inequality as a Business Risk*. Tech. rep. KPMG, 2022. URL: https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2022/05/social-inequality-as-a-business-risk.pdf.

on pure economic efficiency and more on long-term economic resilience. Likewise, this report provides a broad and deep range of literature from which materialist and non-materialist resilience can be better understood. Resilience of these types can be vague, incoherent, and intangible. This report being a central repository of globally respected literature enables it to be a knowledge base from which robust, well-evidenced discussions regarding resilience and wellbeing, from global to local levels, can be facilitated.

5 WHAT IS RESILIENCE

In addressing global adaptive capacity, one must ask the initial questions that pertain to all resilience: resilience of what, and under what kind of shock or stress, over what timeframe, for whom, and to what?[27]

Resilience of What? In general we aim for a resilience of high quality of life informed by Mark Fabian's work on subjective wellbeing,[28] and as perhaps contributed to by definitions of Decent Living Standards[29] and the socio-ecological commons from Elinor Ostrom.[30] This also includes the causal aspects of global trade, production, and policy that enable this. In particular, infrastructure, institutions, and innovations that have especially salient roles to play. We identify food security, industries, and innovations relevant to GCRs; and related professional and expert networks as living systems of practice.

We utilise several frameworks in order to cross-pollinate and harmonise various existing concepts of resilience. Starting with the most abstract conceptual basis, we use Linkov[31] and the Three Horizons Framework[32] as categorisation of resilience components and the processes of systems change respectively. Then we look at larger historically informed macro-trends as explored by Seth Baum et al.[33] Next we aim to concretise these large civilisational risk frameworks with the City Resilience Framework (see Figure 1),[34] bringing the insights of higher order

[27] Alastair McAslan. "The Concept of Resilience: Understanding Its Origins, Meaning and Utility". In: *Torrens Resilience Institute* (2010). URL: https://www.flinders.edu.au/content/dam/documents/research/torrens-resilience-institute/resilience-origins-and-utility.pdf.

[28] Mark Fabian. *A theory of subjective wellbeing*. eng. Philosophy, politics, and economics. New York, NY: Oxford University Press, 2022. ISBN: 978-0-19-763526-1.

[29] Jason Hickel and Dylan Sullivan. "How much growth is required to achieve good lives for all? Insights from needs-based analysis". en. In: *World Development Perspectives* 35 (Sept. 2024), p. 100612. ISSN: 24522929. DOI: 10.1016/j.wdp.2024.100612. URL: https://linkinghub.elsevier.com/retrieve/pii/S2452292924000493 (visited on 06/05/2025).

[30] Elinor Ostrom. "Beyond Markets and States: Polycentric Governance of Complex Economic Systems". en. In: *American Economic Review* 100.3 (June 2010), pp. 641–672. ISSN: 0002-8282. DOI: 10.1257/aer.100.3.641. URL: https://pubs.aeaweb.org/doi/10.1257/aer.100.3.641 (visited on 06/05/2025).

[31] Linkov et al., "Measurable Resilience for Actionable Policy".

[32] Sharpe et al., "Three horizons".

[33] Baum et al., "Long-term trajectories of human civilization".

[34] Resilient Cities Network. *Resilient Cities Network. City Resilience Framework - 2024 Edition*. Tech. rep. 2024.

systems into more tractable locality based analysis. The study of resilience is stronger when instantiated at a local or municipal level, meaning city planners and managers are often leaders in the study of resilience. For example, cities and port authorities can make changes today for greater resilience, if guided by strong evidence and bold thinking. Additionally, this allows us to expand our understanding of persisting nodes of complexities, to encompass trade entrepôts that may serve as 'nodes of persisting recovery.'

These frameworks appreciate that resilience is integrated across social, economic, environmental, technological, and governance domains, and that the resilience of any of these domains depends on the resilience of other domains.

Under what kind of shock or stress? There are a range of shocks and stresses to which resilience can be developed. The City Resilience Framework outlined in Figure 1 highlights the different categories of shocks and stresses, such as shocks and stresses derived from poor public health strains, physical & social infrastructure deficits, social in-cohesion & inequality, and a lack of environmental health & wellbeing.

Over what timeframe? This report focuses on a longer term timeframe than most electoral horizons, as our wider work with the Odyssean Process aims to also enable the public and experts to reason and decide on longer timeframes needed for appropriate resilience to risks, both acute and chronic, both particular and systemic. This is why non-materialist resilience, centred around social and institutional trust, is integral for long-term materialist resilience. As such we are aiming for resilience that ensures our survival and flourishing on the 50-100 and beyond year scale.

Resilience for whom? In answering for whom, we aim to ensure global adaptive capacity, with a mild prioritarian focus on those especially exposed or vulnerable participating directly in decision making about their future. As such 'for whom' covers both developed and developing countries, with all the complex questions regarding what types of development are implicated. The Odyssean Institute's wider forthcoming work on sustainable wellbeing, ecological, and evolutionary economics led development rather than orthodox GDP metrics, is designed to add further definition to this complex problem regarding which modes of livelihood we can expect to be able to preserve.

Resilience to what? Finally, we define resilience as it pertains to societal resistance and ability to recover from civilisational collapse, or catastrophes with millions of casualties, or, indeed, to extinction. We gather these varied GCR, x-risk, collapse, and prolonged stagnation scenarios under the umbrella 'civilisational risk'. This definition captures both recent efforts around GCRs and x-risks as distinct classes of catastrophe, but also broader conceptualisations of long

URL: https://resilientcitiesnetwork.org/city-resilience-framework-2024-edition/.

[35] Network, *Resilient Cities Network. City Resilience Framework - 2024 Edition.*

FIGURE 1: CITY RESILIENCE FRAMEWORK 2024 EDITION[35]

term civilisational collapse[36] such as those around extreme climate change, durable totalitarianism, and historic analyses of collapsed states.[37]

Additionally, frameworks such as Planetary boundaries and doughnut economics infer the ecological carrying capacity upon which we rely, and our ability to meet living standards without transgressing this, respectively Figure 2.

The traditional reliance on GDP as the primary measure of economic success has increasingly come under scrutiny. Critics argue that GDP offers a narrow and parochial view, failing to reflect the complexities of human wellbeing and environmental sustainability, and instead focusing on financial exchange being a direct proxy to value.[38] The singular focus on economic growth as an ultimate goal often neglects broader societal needs, such as equity and environmental health.[39] This critique aligns with the sustainable development discourse, which advo-

[36] Joseph A. Tainter. *The collapse of complex societies*. eng. New studies in archaeology. Cambridge: Cambridge university press, 1990. ISBN: 978-0-521-38673-9.

[37] Peter Turchin. *End times: elites, counter-elites, and the path of political disintegration*. eng. OCLC: 1346153336. New York: Penguin Press, 2023. ISBN: 978-0-593-49050-1.

[38] Rutger Hoekstra. *Measuring the Wellbeing Economy: How to Go Beyond GDP*. tech. rep. WEAll, 2020. URL: https://weall.org/wp-content/uploads/WEAll-BRIEFINGS-Measuring-the-Wellbeing-Economy_3Aug-1.pdf..

[39] Lorenzo Fioramonti et al. "Wellbeing economy: An effective paradigm to mainstream post-growth policies?" en. In: *Ecological Economics* 192 (Feb. 2022), p. 107261. ISSN: 09218009. DOI: 10.1016/j.ecolecon.

cates for balancing economic prosperity, social equity, and environmental sustainability.[40]

Similarly, Len Fisher and Anders Sandberg's review of GCR governance, emphasises the interconnectedness of social, economic, and environmental systems, and how such interconnectedness must be considered in the governance of GCRs.[41] As such, Fisher and Sandberg's work is also a strong starting point for GRAIN's focus on non-material and institutional norms that increase our anticipatory capabilities for specific GCRs and systemic vulnerabilities. This can be complemented by an exploration of policy capacity, encompassing analytical, operational, and political policy capacities at a personal, organisational, and systemic level.[42] Policy capacity measures the ability for governments and society to design, implement, and sustain policy measures in an impactful manner.[43]

5.1 OBSTACLES TO UNDERSTANDING RESILIENCE

While there are common heuristics to understand resilience, there are still cognitive barriers preventing a coherent understanding of resilience of resilience. Notably, there are two key obstacles to an accurate and comprehensive understanding of resilience:

1. Resilience is not just a matter of quantitative risk assessment
2. There is fragmentation in defining the concept of resilience across different disciplines

As Seth Baum et al.[46] explore, some threats are recognised but remain difficult to quantify, as their probabilities and/or magnitudes are considered immeasurable. If these factors were truly

2021 . 107261. URL: https : //linkinghub . elsevier . com / retrieve / pii / S0921800921003207 (visited on 06/05/2025).

[40] Anders Hayden. "The wellbeing economy in practice: sustainable and inclusive growth? Or a post-growth breakthrough?" en. In: *Humanities and Social Sciences Communications* 11.1 (July 2024), p. 879. ISSN: 2662-9992. DOI: 10 . 1057 / s41599 - 024 - 03385 - 8. URL: https : // www . nature . com / articles / s41599 - 024 - 03385 - 8 (visited on 06/05/2025).

[41] Len Fisher and Anders Sandberg. "A Safe Governance Space for Humanity: Necessary Conditions for the Governance of Global Catastrophic Risks". en. In: *Global Policy* 13.5 (Nov. 2022), pp. 792–807. ISSN: 1758-5880, 1758-5899. DOI: 10.1111/1758-5899.13030. URL: https://onlinelibrary.wiley.com/doi/10.1111/1758-5899.13030 (visited on 06/05/2025).

[42] Howlett and Ramesh, "<span style="font-variant".

[43] Wayne Parsons. "Not Just Steering but Weaving: Relevant Knowledge and the Craft of Building Policy Capacity and Coherence". en. In: *Australian Journal of Public Administration* 63.1 (Mar. 2004), pp. 43–57. ISSN: 0313-6647, 1467-8500. DOI: 10.1111/j.1467-8500.2004.00358.x. URL: https://onlinelibrary.wiley.com/doi/10.1111/j.1467-8500.2004.00358.x (visited on 06/05/2025).

[44] Kate Raworth. *Doughnut economics: seven ways to think like a 21st-century economist*. eng. UK USA Canada Ireland Australia India New Zealand South Africa: Penguin Books, 2022. ISBN: 978-1-84794-139-8.

[45] Wu, Ramesh, and Howlett, "Policy capacity".

[46] Seth D. Baum et al. "Resilience to global food supply catastrophes". en. In: *Environment Systems and Decisions* 35.2 (June 2015), pp. 301–313. ISSN: 2194-5411. DOI: 10.1007/s10669-015-9549-2. URL: https://doi.org/10.1007/s10669-015-9549-2 (visited on 10/10/2023).

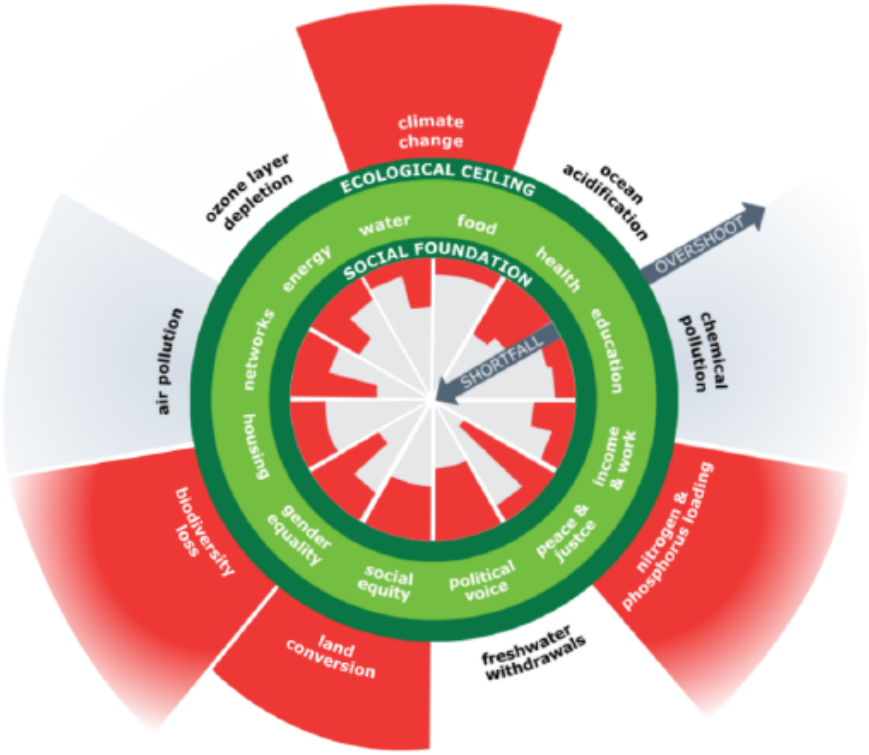

FIGURE 2: DOUGHNUT ECONOMICS HEURISTIC [44]

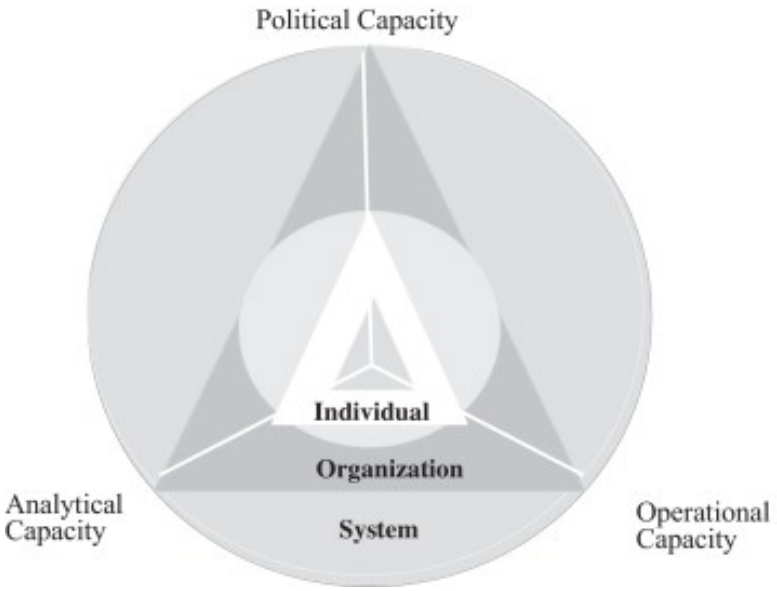

FIGURE 3: POLICY CAPACITY FRAMEWORK [45]

unquantifiable, calculating risk — at least under the standard probability-times-magnitude model — would be impossible. However, some approaches to risk analysis, such as those by Christopher Karvetski and James Lambert, do not require full quantification.[47]

That said, these threats are not entirely unquantifiable; they only appear to be. This situation is similar to that of unknown threats. For a threat to be completely unquantifiable, there would have to be absolutely no information available about its potential scale—a highly stringent condition that rarely holds in practice, even when assumed to. The fact that some information usually exists, however minimal, allows for the application of both risk and resilience frameworks to address these uncertainties effectively.

If a threat is entirely unknown before it occurs, conducting a risk analysis becomes difficult. An analyst will struggle to estimate its probability or potential impact if it lies completely beyond their imagination. Similarly, without any prior knowledge, managing such a risk is unfeasible. However, this does not mean that resilience is a more effective approach in these cases. If a threat is entirely unknown, resilience strategies are just as ineffective as risk-based approaches. A system manager cannot enhance a system's resilience to a threat without some understanding of how it might affect the system.

In reality, most seemingly unknown threats have at least some minimal information associated with them. This small but nonzero knowledge allows both risk and resilience frameworks to be applied. For instance, Nilesh Joshi and James Lambert argue how diversification can be used to manage uncertain risks and enhance societal resilience.[48]

Overall, resilience is a polysemic and contested concept, meaning it carries multiple interpretations across disciplines and contexts. While some view it as the ability to absorb shocks and recover, others emphasise transformation and adaptation in response to change. Despite these differences, there is strong consensus on the importance of systems thinking and long-termism in achieving resilience. Systems thinking acknowledges the interconnectedness of social, ecological, and economic systems, recognizing that resilience cannot be understood or fostered in isolation. Long-termism, on the other hand, ensures that resilience strategies account for future generations, avoiding short-term fixes that may lead to long-term vulnerabilities. Whether applied to climate change adaptation, governance, or global risk management, resilience must be dynamic, inclusive, and forward-looking. By integrating holistic analysis and future-oriented policies, societies can move beyond reactive resilience toward proactive, equitable, and sustainable pathways for navigating uncertainty and change.

[47] Christopher W. Karvetski and James H. Lambert. "Evaluating deep uncertainties in strategic priority□setting with an application to facility energy investments". en. In: *Systems Engineering* 15.4 (Dec. 2012), pp. 483–493. ISSN: 1098-1241, 1520-6858. DOI: 10.1002/sys.21215. URL: https://incose.onlinelibrary.wiley.com/doi/10.1002/sys.21215 (visited on 06/05/2025).

[48] Nilesh N. Joshi and James H. Lambert. "Diversification of infrastructure projects for emergent and unknown non□systematic risks". en. In: *Journal of Risk Research* 14.6 (June 2011), pp. 717–733. ISSN: 1366-9877, 1466-4461. DOI: 10.1080/13669877.2011.553733. URL: http://www.tandfonline.com/doi/abs/10.1080/13669877.2011.553733 (visited on 06/05/2025).

5.2 MATERIALIST RESILIENCE

This report will now explore materialist resilience, looking at both food and non-food factors.

The policy capacity framework in Figure 3 is essential for analysing the role of materialists — such as producers, suppliers, and distributors—in resilient food and non-food systems because it highlights how different levels and types of policy capacity influence systemic outcomes. Organisational policy capacity, in particular, is key to understanding how institutions that coordinate or regulate material flows function in practice. This includes their ability to manage logistics, ensure quality and safety standards, and respond effectively to supply chain disruptions. In food and non-food systems, organisational capacity determines how well institutions can implement policies that secure access, equity, and sustainability across diverse populations and geographies.

Strong organisational capacity enables institutions to translate strategic goals into operational realities by aligning internal structures, expertise, and processes. It allows for adaptive supply chain management, real-time monitoring, and efficient resource allocation—all of which are critical for ensuring the resilience of essential systems. This, in turn, supports societal well-being by safeguarding livelihoods, maintaining price stability, and ensuring continued access to food, water, energy, and other essential goods during disruptions. Conversely, weak organisational capacity can result in bottlenecks, regulatory failures, and social inequalities in times of stress. The policy capacity framework in Figure 3 provides a valuable lens through which to identify and enhance the organisational capacities needed to support resilient, equitable, and sustainable material systems.

5.2.1 FOOD

Food security and resilience require a multi-pronged approach, particularly in the context of global catastrophic risks (GCRs). In this context, especially severe but neglected tail end risks such as abrupt sunlight reduction scenarios (ASRS). The information provided highlights a range of food sources that can play a crucial role in mitigating food shortages, ensuring nutritional adequacy, and stabilising supply chains in crisis conditions. Using the Linkov Matrix framework (Absorb, Recover, Adapt), we can analyse how these food systems contribute to resilience across different phases of disruption and recovery.

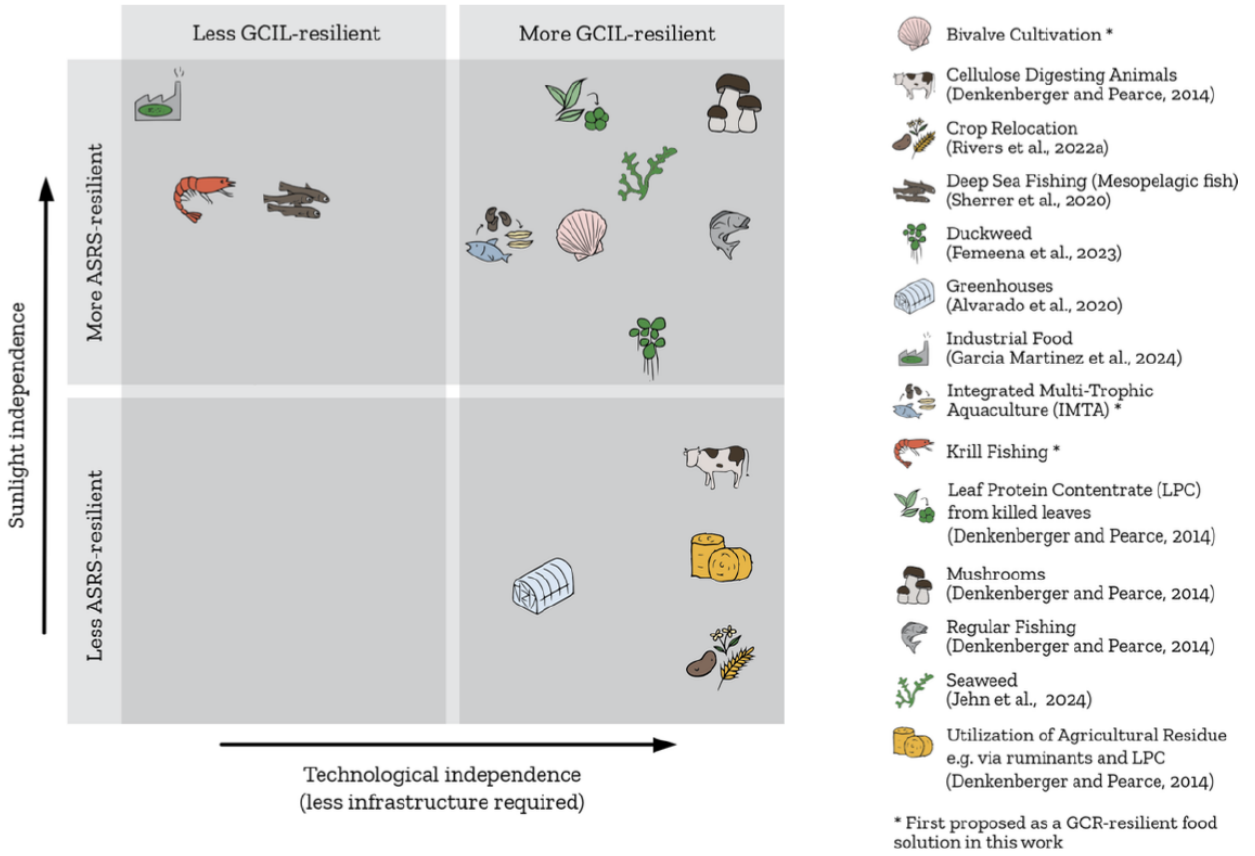

FIGURE 4: MAPPING THE RESILIENCE OF FOOD PRODUCTS, BASED ON SUNLIGHT INDEPENDENCE AND TECHNOLOGICAL INDEPENDENCE [49]

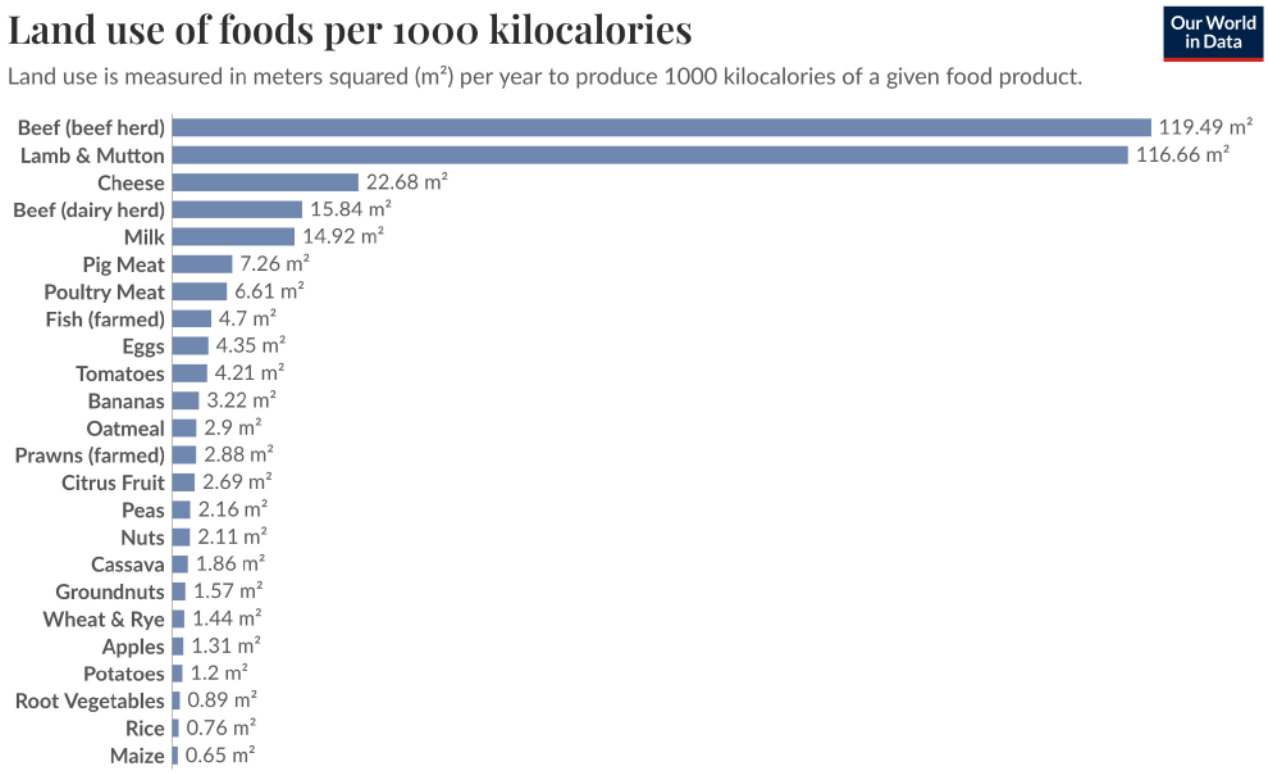

FIGURE 5: LAND USE OF FOODS PER 1000 KILOCALORIES[50]

FOOD SOURCES AND THEIR RESILIENCE CONTRIBUTIONS

In general, there exist correctives to exposure to catastrophic food systems failure, or compounding other risks through unsustainable practices. For near-term climatic resilience, these include investing in permaculture and agroforestry, to avoid biodiversity collapse or monocultural dependence (including on extremely unequal agricultural oligopolies). Redirection of food stuffs from animal feed to human use can also drastically improve our ineffective land use.[51]

Just as meat and dairy in the past were luxuries for the few, in times of crises, it is important to recognise that we can recover significant land-use and even survive on existing foodstock designed for animals after curling them for initial survival.[52]

Further emphasis on the need for less monocultural and ecology straining agriculture, through agroecological approaches, such as permaculture and agroforestry, themselves potentially viable through administrative innovations such as bioregional administration zones, is also instructive for general food systems resilience.[53]

These can also be complemented by more technical interventions, for example those pertaining to ASRS scenarios (and even more extreme climatic outcomes, albeit lower frequency)[54] listed below.

RESILIENCE FOOD FOR MORE SEVERE GLOBAL CATASTROPHES SUCH AS ASRS

Seaweed as a Scalable Aquaculture Solution. Seaweed farming presents a highly scalable, resource-efficient food production system that does not compete with land-based crops for

[49] Juan B. García Martínez et al. "Resilient foods for preventing global famine: a review of food supply interventions for global catastrophic food shocks including nuclear winter and infrastructure collapse". en. In: *Critical Reviews in Food Science and Nutrition* (Feb. 2025), pp. 1–27. ISSN: 1040-8398, 1549-7852. DOI: 10.1080/10408398.2024.2431207. URL: https://www.tandfonline.com/doi/full/10.1080/10408398.2024.2431207 (visited on 06/05/2025).

[50] Hannah Ritchie. *If the World Adopted a Plant-Based Diet, We Would Reduce Global Agricultural Land Use from 4 to 1 Billion Hectares*. Apr. 2021. URL: https://ourworldindata.org/land-use-diets.

[51] Hannes Dempewolf, Sarada Krishnan, and Luigi Guarino. "Our shared global responsibility: Safeguarding crop diversity for future generations". en. In: *Proceedings of the National Academy of Sciences* 120.14 (Apr. 2023), e2205768119. ISSN: 0027-8424, 1091-6490. DOI: 10.1073/pnas.2205768119. URL: https://pnas.org/doi/10.1073/pnas.2205768119 (visited on 06/05/2025).

[52] Ritchie, *If the World Adopted a Plant-Based Diet, We Would Reduce Global Agricultural Land Use from 4 to 1 Billion Hectares*.

[53] Raychel Santo and Ana Moragues-Faus. "Towards a trans-local food governance: Exploring the transformative capacity of food policy assemblages in the US and UK". en. In: *Geoforum* 98 (Jan. 2019), pp. 75–87. ISSN: 00167185. DOI: 10.1016/j.geoforum.2018.10.002. URL: https://linkinghub.elsevier.com/retrieve/pii/S0016718518302963 (visited on 06/05/2025).

[54] Lili Xia et al. "Global food insecurity and famine from reduced crop, marine fishery and livestock production due to climate disruption from nuclear war soot injection". en. In: *Nature Food* 3.8 (Aug. 2022), pp. 586–596. ISSN: 2662-1355. DOI: 10.1038/s43016-022-00573-0. URL: https://www.nature.com/articles/s43016-022-00573-0 (visited on 06/05/2025).

critical inputs like freshwater, fertilizers, and pesticides. In post-ASRS conditions, colder sea temperatures can bring nutrient-rich waters to the surface, further enhancing seaweed growth. Studies suggest that seaweed could contribute up to 45% of human food demand over a decade,[55] making it a crucial component of food system recovery. Its ability to absorb shocks, recover quickly, and adapt to changing environmental conditions underlines its importance for food resilience.

Mushrooms as a Micronutrient-Dense Supplement. While mushrooms are not calorie-dense, they offer vital micronutrients and can be enriched with Vitamin D through UV exposure. They can be cultivated with minimal resources, making them an accessible food source for household and small-scale production. Given their suitability for ASRS environments, mushrooms provide an important supplement to staple diets, ensuring micronutrient security in crisis conditions.[56] Their absorptive and adaptive capacity makes them well-suited for resilient food systems.

Cold-Resistant Staple Crop Relocation for Sustained Caloric Supply. Relocating cold-resistant crops such as potatoes, wheat, barley, and sugar beets to lower latitudes is a pragmatic strategy for ensuring food availability after climatic shocks. Additionally, low-tech greenhouses could further expand the cultivation range of these crops, ensuring year-round productivity. By securing stable staple crop production, this strategy supports the absorption and recovery phases of resilience, reducing dependency on external food imports.

Single-Cell Protein (SCP) and Synthetic Fat as High-Efficiency Alternatives. SCP, derived from methanotrophic bacteria using natural gas, offers a high-caloric, protein-rich alternative to traditional food sources. It can supply 19-31% of caloric needs post-ASRS, providing a valuable nutritional supplement, particularly in regions where conventional agriculture is disrupted. However, SCP production is capital-intensive, requiring LNG and biogas infrastructure, and ramp-up can be slow. While SCP's dependence on fossil fuel infrastructure presents a limitation, its potential for legacy industrial repurposing (such as Project Willow in the recent shutdown of Grangemouth oil refinery)[57] and sustainability makes it a key component of future food resilience strategies.

Leaf Protein Concentrate and Lignocellulosic Sugar for Alternative Carbohydrate. Lignocellulosic sugar, derived from wood conversion, offers a carbohydrate source that does not

[55] Florian Jehn et al. *Food trade disruption after global catastrophes*. July 2024. DOI: 10.31223/X5MQ4R. URL: https://eartharxiv.org/repository/view/7339/ (visited on 06/05/2025).

[56] David Denkenberger and Joshua M. Pearce. *Feeding Everyone No Matter What: Managing Food Security After Global Catastrophe*. en. Google-Books-ID: zP2cBAAAQBAJ. Academic Press, Nov. 2014. ISBN: 978-0-12-802358-7.

[57] Scottish Enterprise. *Project Willow: An Opportunity to Establish a Low Carbon Manufacturing Hub in Scotland's Industrial Heartland*. Tech. rep. 2024. URL: https://www.sdi.co.uk/media/vlubfykz/project-willow-public-information-document.pdf.

compete with traditional crops for land and water. These solutions align with high-efficiency agricultural models seen in Dutch hydroponics and climate-controlled greenhouses, which maximize productivity per unit of resource input. Such adaptive approaches are essential for securing food supplies under extreme conditions.

A summary of an analysis of food resilience is in Appendix A.

5.2.2 NON-FOOD

Resilience, particularly in a materialist sense, is underpinned by the ability of infrastructure, supply chains, and energy systems to absorb, recover, and adapt in the face of catastrophic disruptions. This perspective is crucial when analysing key industrial components such as liquefied natural gas (LNG), semiconductors, metals, electricity grids, port infrastructure, and high-tech greenhouses — all of which form the backbone of a functioning, resilient society.

Likewise, as a last resort, this may include retaining coal and oil reserves for potential re-industrialisation. Although this might seem counter-intuitive to combating many climate-change induced crises, they remain humanity's most easily accessible and easy to transport fuel due to their high immediate Energy-Return on Investment (ERoI) which has been subsidised by our past extraction and exploration.[58]

In addition, there is an imperative for circular economy practices to be pursued in order to preserve materials that might otherwise be wasted, particularly in the context of a global shock or stress.[59]

Liquefied Natural Gas (LNG) and Its Critical Role. LNG continues to be a major energy source, not just for direct use but also as a critical input in electricity generation. More importantly, LNG plays an indirect but essential role in food security, as it is a precursor for nitrogen-based fertilizers and can also be converted into methane-based Single-Cell Protein, providing a novel resilience food source. However, LNG infrastructure is highly energy-intensive, requiring cryogenic storage, making its recovery contingent on the rapid restoration of power systems. It also remains a significant contributor to greenhouse gas emissions, for both its convenience as an ostensibly 'cleaner' fossil fuel but also with leakage in both existing infrastructure and under-regulated areas. Yet, it is because of LNG's low immediate ERoI in recovery scenarios as well as natural gas potential to be converted into resilience foods (which have elaborated above, that underscores a possible role in analysing resilience through the Linkov Matrix. LNG could

[58] Nathan J. Hagens and D. J. White. "Energy Part 9 - Energy Properties and Renewables". en. In: *Reality Blind: Integrating the Systems Science Underpinning Our Collective Futures.* Vol. 1. Google-Books-ID: DYYJ0QEACAAJ. NJ Hagens and DJ White, 2021. ISBN: 9798701116281.

[59] Mingyu Yang et al. "Circular economy strategies for combating climate change and other environmental issues". en. In: *Environmental Chemistry Letters* 21.1 (Feb. 2023), pp. 55–80. ISSN: 1610-3653, 1610-3661. DOI: 10.1007/s10311-022-01499-6. URL: https://link.springer.com/10.1007/s10311-022-01499-6 (visited on 06/09/2025).

contribute to absorbing shocks, recovering energy supply chains, and adapting by finding alternative uses in food systems; especially if it is shifted from a large role in energy to a specific role as a backstop for resilience (reducing our exposure to its greenhouse gas emitting role).

Semiconductors: The Fragile Pillars of a High-Tech Society. Semiconductors are integral to modern economies, enabling advanced computing, communications, and modelling necessary for managing crises. However, their production is concentrated in Taiwan, a geopolitically volatile region susceptible to both conflict and natural disasters such as volcanic eruptions.[60] This centralisation poses a major resilience challenge, as disruptions could cripple global technological infrastructure, requiring a mix of recovery and adaptation strategies to maintain supply chain stability.

Metals: The Skeleton of Infrastructure and Supply Chains. Steel, aluminium, and copper form the physical foundation of industrial and technological infrastructure. Steel is indispensable for transport, logistics, and energy systems, while copper plays a critical role in communications infrastructure, from submarine cables to land-based networks. Any collapse in the global metals industry could significantly delay post-disaster recovery, hindering essential trading connections. Furthermore, power grids rely on aluminium and steel for power lines, making their availability crucial for restoring electricity after disasters, emphasising the necessity of maintaining these industries for resilience.[61]

Electricity Grid Backups and Contingency Planning. A resilient electricity grid is fundamental to all other systems, from food supply chains to industrial production. Stockpiling transformers and other critical components could expedite grid restoration after a global catastrophe, such as a high-altitude nuclear electromagnetic pulse (HEMP) or a global catastrophic risk (GCR). Studies indicate that prolonged grid failure could reduce caloric consumption by up to 65% due to food supply chain disruptions, highlighting the cascading impacts of energy system failure on societal resilience.[62]

Port Infrastructure at Maritime Chokepoints. Maritime chokepoints, such as the Strait of Malacca and the Suez Canal, are critical nodes in global trade. Disruptions at these points could cause cascading failures in the delivery of food, fuel, and other essential goods. Strategic planning and investment in port resilience—particularly in scenarios of large-scale crises

[60] Lara Mani, Asaf Tzachor, and Paul Cole. "Global catastrophic risk from lower magnitude volcanic eruptions". en. In: *Nature Communications* 12.1 (Aug. 2021), p. 4756. ISSN: 2041-1723. DOI: 10.1038/s41467-021-25021-8. URL: https://www.nature.com/articles/s41467-021-25021-8 (visited on 06/05/2025).

[61] Vaclav Smil. *Energy transitions: global and national perspectives*. eng. Second edition. Santa Barbara, California: Praeger, 2016. ISBN: 978-1-4408-5324-1 978-1-4408-5325-8.

[62] Simon Blouin et al. "Assessing the Impact of Catastrophic Electricity Loss on the Food Supply Chain". en. In: *International Journal of Disaster Risk Science* 15.4 (Aug. 2024), pp. 481–493. ISSN: 2095-0055, 2192-6395. DOI: 10.1007/s13753-024-00574-6. URL: https://link.springer.com/10.1007/s13753-024-00574-6 (visited on 06/05/2025).

like nuclear conflict—can mitigate extreme food insecurity. Maintaining trade flows, even in worst-case scenarios, could meet 19% of global nutritional requirements. Complex adaptive system modelling underscores the need for robust contingency plans to reroute trade in times of crisis.[63]

High-Tech Greenhouses for Food Security. High-tech greenhouses offer a proactive resilience strategy by enabling controlled-environment agriculture, ensuring food production in extreme climate conditions. However, they remain vulnerable to energy blackouts, limiting their applicability in scenarios involving widespread infrastructure collapse. Decision-making under deep uncertainty (DMDU) frameworks must consider these constraints when evaluating long-term food security strategies.

Government Procurement and Investment in Resilience. Government-led investment in resilience to food and material production, such as R&D grants and debt-equity models, can drive innovation in critical non-food sectors. Australia's reconstruction fund approach exemplifies how state intervention can enhance the resilience of essential supply chains. Public-private partnerships in resilience-building efforts remain key to long-term systemic adaptation.

A summary of an analysis of non-food resilience is in Appendix F.

We now turn to initial mapping of key hubs for global adaptive capacity: resilient nodes of persisting complexity, and trade cruxes for bundles of key representative goods, seen as nodes of persisting recovery when displaying disproportionate advantages across indices of several key goods.

5.2.3 REVEALED COMPARATIVE ADVANTAGE

Revealed Comparative Advantage (RCA) is an index used in international economics to determine whether a country has a relative advantage or disadvantage in the production and export of a particular good or service, compared to the rest of the world.[64] It measures the extent to which a country exports a certain product more intensively than the global average.[65]

It can be calculated through the following formula:

$$\text{RCA}_{ij} = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{wj}}{X_{wt}}}, \tag{1}$$

where X_{ij} represents the exports of product j by country i, X_{it} is the total exports by country i, X_{wj} is the world exports of product j, and X_{wt} is total world exports.

[63] William Komiss and LaVar Huntzinger. *The Economic Implications of Disruptions to Maritime Oil Chokepoints*. Tech. rep. CNA, Mar. 2011. URL: https://www.cna.org/reports/2011/D0024669.A1.pdf.

[64] French, "Revealed comparative advantage".

[65] Bela Balassa. "Trade Liberalisation and "Revealed" Comparative Advantage[1]". en. In: *The Manchester School* 33.2 (May 1965), pp. 99–123. ISSN: 1463-6786, 1467-9957. DOI: 10.1111/j.1467-9957.1965.tb00050.x. URL: https://onlinelibrary.wiley.com/doi/10.1111/j.1467-9957.1965.tb00050.x (visited on 06/05/2025).

In the context of RCA, an RCA value of more than one suggests that a country has a revealed comparative advantage in a particular product. Conversely, an RCA of less than one is a country that has a revealed comparative disadvantage in a particular product.

The City Resilience Framework in Figure 1 is essential for analysing the resilience of port cities due to its holistic and systems-based approach. Port cities are critical nodes in global trade networks, and their resilience directly affects the continuity of international supply chains and economic stability. The CRF enables a comprehensive assessment that includes not just physical infrastructure, but also governance systems, social dynamics, economic health, and environmental factors. This is particularly important as port cities face compound risks from climate change, geopolitical instability, and infrastructure strain. By applying the CRF, stakeholders can identify interdependencies and vulnerabilities across urban systems that impact port operations and trade flows. Moreover, the framework supports the development of integrated resilience strategies that align local priorities with global trade imperatives. Ultimately, using the CRF ensures that port cities can adapt, recover, and thrive amidst disruptions, safeguarding the resilience of global trade stocks and flows.

RCA is a useful tool for understanding nodes of persisting complexity and recovery in the context of global trade stocks and flows, but also the nodes of vulnerability. In light of highly integrated global supply chains, even a single point of failure can undermine the economic efficiency and wellbeing of countries, regions, or the world. A recent example from 2021 is the blockage of the Suez Canal by the freight ship 'Evergreen', which severely disrupted international trade for up to a month.[66] This is especially harmful in the context of critical food and non-food materialist resilience, as disrupting the flows of these products can have serious global consequences.

COVID-19 demonstrated the fragility of the international trading system in various commodities, including global food supply chains[67] and pharmaceutical supply chains.[68] In addition, the global race towards AI supremacy and global net zero ambitions mean goods like semiconductors and critical minerals are also key commodities that can enable or disable the sustained resilience and productivity of global economies.[69]

[66] "Egypt's Suez Canal blocked by huge container ship". en-GB. in: *BBC News* (Mar. 2021). URL: https://www.bbc.com/news/world-middle-east-56505413 (visited on 06/05/2025).

[67] Michael Omotayo Alabi and Ojelanki Ngwenyama. "Food security and disruptions of the global food supply chains during COVID-19: building smarter food supply chains for post COVID-19 era". en. In: *British Food Journal* 125.1 (Jan. 2023), pp. 167–185. ISSN: 0007-070X. DOI: 10.1108/BFJ-03-2021-0333. URL: https://www.emerald.com/insight/content/doi/10.1108/BFJ-03-2021-0333/full/html (visited on 06/05/2025).

[68] Andrew D. Mitchell. "The Geography of Health: Onshoring Pharmaceutical Manufacturing to Address Supply Chain Challenges". en. In: *World Trade Review* 23.4 (Oct. 2024), pp. 519–531. ISSN: 1474-7456, 1475-3138. DOI: 10.1017/S1474745624000387. URL: https://www.cambridge.org/core/product/identifier/S1474745624000387/type/journal_article (visited on 06/05/2025).

[69] Nayantara Hensel. "Challenges and Opportunities in Global Supply Chains: The Role of Critical Minerals". In: *Prism* 10.3 (2023), pp. 59–80. URL: https://ndupress.ndu.edu/Media/News/News-Article-View/Article/3512099/challenges-and-opportunities-in-global-supply-chains-the-role-of-critical-

When such vulnerability is exposed, it is imperative that countries and companies recognise the countries that have a revealed comparative advantage in these key products, but also which ones do not.

In this sense, RCA allows firms and governments to identify nodes of resilience and recovery in global trade. For example, Singapore has an RCA of 24.58 in seaweed exports, meaning if there is a global shortage of seaweed, Singapore can become a node of global resilience in stocks and flows of seaweed exports. Additionally, Switzerland has an RCA of 37.34 in sugar beet, and sugar beet is a resilience-relevant commodity necessary for many global food products. The fact Switzerland has a strong RCA in sugar beet means it can serve as a node for trade resilience in the event of a disruption to global food stocks and flows.

RCA can also help individual countries identify other nodes of trade that can support them, and that they can support, in the event of trade disruptions. For example, Singapore has an RCA value of 0.17 for semiconductors, but has an RCA of 3.53 in Liquefied Natural Gas (LNG). Meanwhile, Macau has an RCA value of 3.60 in semiconductors but only an RCA of 0.10 in LNG. So in the event of global semiconductor supply chains being disrupted, Singapore might want to collaborate with Macau to import more semiconductors, with the agreement to export more LNG to Macau.

RCAs are based on Harmonised System (HS) Codes, HS codes are internationally standardised numerical classifications used to identify traded goods for the purpose of correct tariff application. However, HS codes have some key flaws, which affect the reliability of RCA values. Namely:

- inconsistent categorisation across countries (only HS-6-level are internationally standardised, with HS-8+ varying between countries),
- Periodic revisions of the codes affecting comparability over time,
- Incomplete or aggregated reporting in datasets, and discrepancies between declared and actual traded goods due to differences in enforcement or compliance.

Regardless, RCA works well in the context of understanding food and non-food materialist resilience, and is a commonly used measure in understanding the nature of global trade stocks and flows. When extrapolated, this can help understand the nodes of persisting complexity and recovery across global trade.

Table 1 presents Revealed Comparative Advantage (RCA) values for five countries across three tradable goods: LNG, semiconductors, and seaweed. RCA values above one indicate a

miner/; Xuefeng Zhang, Yutan Zhang, and Guo Li. "Strategic inventory in semi-conductor supply chains under industrial disruption". en. In: *International Journal of Production Economics* 272 (June 2024), p. 109254. ISSN: 09255273. DOI: 10.1016/j.ijpe.2024.109254. URL: https://linkinghub.elsevier.com/retrieve/pii/S0925527324001117 (visited on 06/05/2025).

	LNG	Semiconductors	Seaweed
Singapore	3.53	3.53	24.58
Macau	0.10	3.60	0.08
China	0.00	0.04	0.06
Switzerland	0.00	0.30	0.08
Italy	0.04	0.06	0.48

TABLE 1: COMPARATIVE RCA VALUES

comparative advantage in a given product. Singapore demonstrates strong comparative advantages in all three sectors, particularly in seaweed (RCA of 24.58), suggesting a significant role in re-exporting or value-added trade. Its high RCA in LNG and semiconductors (both 3.53) reinforces its status as a regional trade hub.

Macau exhibits a revealed comparative advantage only in semiconductors (RCA of 3.60), perhaps demonstrating its capacity as a strong re-exporter of semiconductors, particularly from mainland China. Conversely, China—typically a major player in global trade—shows very low RCA values across all three goods, likely reflecting high domestic consumption or a complex role within global supply chains rather than low production. Although, in the case of semiconductors, it's possible China is conducting export through proxy regions like Macau and Hong Kong. Semiconductors are only manufactured by a handful of global companies, meaning there is low diversification in the export pathways of the product.

Switzerland and Italy display no revealed comparative advantages in any of the goods, with all RCA values well below one. Italy's slightly higher RCA in seaweed (0.48) may indicate some minor specialisation.

Overall, the data highlights Singapore's multi-sectoral export strength, Macau's niche advantage, and the contrast between China's known production capabilities and its low proportional export intensity in these sectors. It also underscores the limited trade specialisation of Switzerland and Italy in this specific product set.

Table 2 presents Revealed Comparative Advantage (RCA) values for the established 'nodes of persisting complexity', Australia, New Zealand, the United Kingdom, Iceland, and Ireland. In King & Jones these were posited as more holistically or structurally resilient due to domestic energy production, agricultural capacity, etc. However, here, our analysis focuses on their role in wider commodity flows globally, with RCA analysis identifying their advantages across three commodities: seaweed, aluminium, iron and steel. RCA values above one signal a comparative advantage. Among the countries assessed, Ireland stands out with a strong RCA of 5.27 in iron and steel, suggesting significant export specialisation in this sector. New Zealand shows a notable RCA of 1.64 in aluminium, reflecting a competitive position in global aluminium exports.

Australia exhibits a moderate comparative advantage in iron and steel (1.15), but surpris-

	Seaweed	Aluminium	Iron and Steel
Australia	0.00	1.64	1.15
New Zealand	0.00	3.60	0.80
United Kingdom	20.03	0.00	0.00
Iceland	0.23	0.00	0.29
Ireland	2.50	0.66	5.27

TABLE 2: NODES OF PERSISTING COMPLEXITY

ingly shows no RCA in aluminium, despite being a major global exporter of it; possibly due to the proportional dominance of other export sectors.

The United Kingdom stands out with an exceptionally high RCA in Seaweed (20.03), positioning it as a dominant node in this niche bioeconomy. This suggests long-term entanglement in supply chains, regulation, and innovation tied to seaweed, perhaps due to conducive marine ecosystems or established processing capacity. Ireland, with a more modest RCA (2.50), shares in this complexity, albeit to a lesser extent. In contrast, Australia and New Zealand (0.00) are outside this node entirely.

New Zealand emerges as a significant node for Aluminium (RCA 1.64), likely tied to energy-intensive smelting operations powered by renewables, reinforcing structural dependencies on both global aluminium markets and local energy infrastructure. Ireland (0.66) and Australia (0.13) are peripheral, while Iceland and the UK are absent from this domain.

Ireland's high RCA in Iron and Steel (5.27) and Australia's moderate RCA (1.15) mark them as active nodes in global metallurgy value chains. These countries are likely embedded in enduring industrial and policy frameworks surrounding steel, from environmental regulation to trade partnerships.

Overall, RCA values reveal not only current trade strengths but also deeper institutional and systemic linkages that define each country's role in complex commodity networks.

From a systems perspective, countries with revealed comparative advantages in niche yet essential materials, or as custodians of key trade routes, can act as 'nodes of persisting recovery' - actors that disproportionately influence supply chains due to strategic specialisations. Putting this novel category in dialogue with the original nodes of persisting complexity, we see that Ireland's position in iron and steel, for example, reflects embedded expertise and infrastructure that may serve as a crucial input node for European or global manufacturing networks. Similarly, New Zealand's RCA in aluminium suggests its importance within specific high-energy, low-emissions material chains.

In contrast, Australia's modest RCA in iron and steel, despite being a major resource exporter, indicates its role as a primary commodity supplier may not always translate into comparative advantage in trade flows. This supports the idea that being a node of complexity, if we

	Stand-out RCA	Tradable Good
Indonesia	41.74	CDAs (meat)
Bangladesh	41.38	LNG
Romania	80.97	Field Bean
Italy	68.28	Rye
Fiji	60.82	Potash

TABLE 3: NODES OF PERSISTING RECOVERY

are not to aim for solely the survival of global civilisation in such shelters, but rather to scale them through trade, means they can connect with, and buttress their potential as, nodes of persisting recovery also. This is not just about volume, but about interconnectivity, specialisation, and resilience within global value chains.

Meanwhile, Table 3 showcases exceptionally high Revealed Comparative Advantage (RCA) values for five countries, each in a distinct tradable good. These values—ranging from 41.38 to 80.97—highlight deep export specialisations that significantly surpass global norms. Romania's RCA of 80.97 in field bean exports is the highest, suggesting a commanding global role in this commodity, likely rooted in agricultural suitability and low domestic demand. Italy's 68.28 RCA in rye reflects a focused agricultural niche, possibly linked to culinary markets or climate-specific advantages.

As such, in the context of global catastrophic risks—such as pandemics, climate disruption, or supply chain collapse—countries with extreme RCA in critical goods can become 'nodes of persisting recovery'. These are actors capable of supplying essential inputs or stabilising key sectors during shocks.

For instance, Fiji's leadership in potash exports positions it as a critical node for agricultural recovery, enabling food production even under constrained conditions. Fiji emerges as a major exporter of potash, through operating as a Pacific transshipment entrepôt, an essential agricultural input, despite its small size, indicating a strategic position in global fertilizer supply chains. Indonesia's dominance in CDAs (meat) underlines its significance in food aid and processed meat exports, while Bangladesh's RCA of 41.38 in LNG is especially notable, hinting at a unique re-export or logistics capacity within global energy markets.

It is also imperative for such trade entrepôt to develop stockpiles of critical goods, to pre-position supplies to be deployed when needed.[70] A global analysis of this kind may succeed this report, to look at purely humanitarian instead of trade commodities.

Likewise, Indonesia's specialisation in CDAs offers emergency food support infrastructure

[70] Lina Frennesson et al. "Localisation of logistics preparedness in international humanitarian organisations". en. In: *Journal of Humanitarian Logistics and Supply Chain Management* 11.1 (Dec. 2020), pp. 81–106. ISSN: 2042-6747. DOI: 10.1108/JHLSCM-06-2020-0048. URL: https://www.emerald.com/insight/content/doi/10.1108/JHLSCM-06-2020-0048/full/html (visited on 06/09/2025).

vital for humanitarian responses. Similarly, Romania and Italy, through their high RCA in resilient grains (field beans, rye), can provide essential plant-based protein and caloric sustenance in times of global disruption.

Bangladesh's LNG trade position may also support energy resilience, especially for regions reliant on LNG imports. These countries, despite their modest overall economic influence, become leverage points for targeted, high-impact interventions in global recovery efforts. Their embeddedness in specific resource flows makes them indispensable nodes for stabilizing complex systems in times of stress—illustrating how hyper-specialisation can equate to resilience, not just vulnerability.

Together, these countries illustrate the value of sectoral specialisation. Even smaller economies like Fiji and Bangladesh can achieve strategic trade relevance by focusing intensely on a single commodity. Their extreme RCA values suggest high integration into specific global value chains, enabling influence that outweighs their broader economic scale.

One way to explain this is the Logistics Performance Index (LPI) of smaller countries. LPI assesses a country's logistics performance based on six key dimensions: customs clearance, infrastructure quality, ease of arranging shipments, logistics services quality, tracking and tracing, and timeliness of shipments.[71]

The LPI uses a survey-based approach, collecting data from international freight forwarders and express carriers to gauge the "logistics friendliness" of different countries.

Furthermore, due to the systemic complexity and sheer quantity—and quality of specific economic conditions, state capacities, and the more intricate interconnections of these—analysis also benefits from looking at bundles of goods, and which nodes of persisting recovery might be suggested in these more cumulative groupings.

Appendix C demonstrates country-level index values of total RCA across all commodities—looking beyond just the RCA formula, and looking at other variables. This includes variables such as LPI, GDP, Mean RCA, Human Development Index (HDI) and Energy Production. These factors determine the overall RCA rating of each country, which can be extrapolated to understand the variables determining supply chain maturity and resilience.

Importantly, Appendix C has a particular weighting that determines rankings. Specifically:

- Mean RCA = 60% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 10% weighting
- LPI = 10% weighting

[71] World Bank. *Connecting to Compete 2023: Trade Logistics in an Uncertain Global Economy*. 2023. URL: https://lpi.worldbank.org/ (visited on 06/05/2025).

For example, Fiji has a relatively modest overall RCA index of 1.11, largely due to its energy production factor of 0.00. Likewise, Indonesia has an overall RCA index of 1.07, with an average commodity RCA of 3.40 and an HDI of 3.00. This is despite its large GDP.

Meanwhile, Italy has an overall RCA index of 3.41, which is high, largely due to Italy's high LPI, GDP and HDI. Therefore, human development and infrastructural robustness are key to overall RCA scoring, rather than just pure economic comparative advantage.

The implication is that for developing countries, high RCA in select commodities may not translate into a strong overall RCA unless supported by systemic enablers. Developed countries, with advanced infrastructure and higher development indicators, act as 'nodes of persisting complexity' that reinforce and diversify their RCA across multiple sectors.

More examples of this can be seen in Appendix Item 3, which shows the top 25 global countries as per the overall RCA index. It demonstrates the role of factors beyond commodity-specific RCA to analyse the total holistic RCA of each country.

Appendix D shows what happens when the weightings are more equalised, and demonstrates how particular variables can substantially influence the RCA index ratings.

In Appendix D, the weightings are:

- Mean RCA = 30% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 20% weighting
- LPI = 30% weighting

In this weighting, the order changes significantly, especially demonstrating the role of LPI and HDI in influencing the total RCA index. For example, countries such as China, with large GDPs and a relatively high LPI, become the first-ranked country, overtaking Italy, despite Italy's higher HDI.

Likewise, Singapore becomes the 6th highest ranked country, compared to the 2nd lowest ranked in the original weighting. This is because LPI and HDI play a bigger role in the adjusted weighting, which compensates for Singapore's relatively low GDP and energy production.

Other papers analysing the capacity of countries' role as a node of persisting complexity highlight how latitude plays a key geographic role in determining its role as a node of persisting complexity.[72] If global average temperatures increase by 4°C, much of the land in the tropical and subtropical latitudes may become unproductive and depopulated.[73]

As such, latitude can influence a country's ability to be a node of persisting complexity and recovery.

[72] King and Jones, "An Analysis of the Potential for the Formation of 'Nodes of Persisting Complexity'".
[73] King and Jones, "An Analysis of the Potential for the Formation of 'Nodes of Persisting Complexity'".

If we account for this, Appendix E is the new ranking. In Appendix E, the weightings are:

- Mean RCA = 50% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 10% weighting
- LPI = 10% weighting

This offers an interesting comparison between Appendix C and Appendix E. The inclusion of latitude as a variable in the index—weighted at 10% and favouring countries further from the equator—has produced notable shifts in the rankings compared to Appendix C.

Countries at higher latitudes, such as Finland, Estonia, Lithuania, and Switzerland, experienced modest to significant improvements in their index scores. Finland, for instance, rose in ranking due to its high latitude and already strong performance in HDI and LPI. Similarly, Estonia and Lithuania saw their positions improve, leveraging their geographic location alongside steady socioeconomic metrics.

Conversely, countries situated closer to the equator—such as Indonesia, Papua New Guinea, and Fiji—were adversely affected. Despite strong performance in RCA or energy production, their low latitudes penalised them in the updated index, reflecting a lower likelihood of sustaining complexity in the context of global catastrophic risks.

Notably, New Zealand is absent from the dataset but would likely perform very well under this revised model due to its high latitude and other favourable metrics, aligning with the literature on 'nodes of persisting complexity'. Meanwhile, tropical nations like Mozambique and Eswatini, previously buoyed by high RCA scores, saw downward shifts in ranking, despite maintaining some relative resilience in trade specialisation.

Overall, the integration of latitude introduces a geographic resilience dimension to the index, emphasising the role of climatic and geographic insulation in long-term systemic survival, particularly under scenarios of global collapse or disruption.

Finally, although some analysis was undertaken on more complex and high tech goods (e.g. the inclusion of semiconductors) which can consist of multiple HS-code precursors, further analysis would need to be made to understand how more intricate components of more technologically advanced production, and civilisation, could be sustained. For the purposes of this report, we use the simpler tier of goods more easily captured by single or a few HS-codes, to enable a more accessible introduction to these approaches.

5.3 NON-MATERIALIST RESILIENCE

The following section analyses domains of non-materialist resilience - specifically, institutional resilience. This includes social trust, trust in government, evidence-based policymaking and

epistemic robustness in decision making, including the role of policy (in)capacity in institutional resilience. Additionally, it analyses the role of industrial policy in generating localised economic development, therefore achieving principles of the wellbeing economy.

5.3.1 INTRODUCTION

In conjunction with the material aspect required to satisfy our basic human needs, resilience against civilisational and catastrophic risks also requires us to reexamine our current approach to governmental policy and decision making. The non-materialist typology identifies the various policy capacities and shortcomings of current governmental capacity and subsequent policy formulation process that needed overhauling, in order to address the need for equitable and democratic resilience.

Specific themes this relates to include:

- Democratic transparency
- Epistemic Institutions
- Research and Development
- Social Trust
- Wellbeing Economics

Appendix F provides more details about these different themes of non-materialist resilience.

The policy capacity framework in Figure 3 is crucial for analysing institutional resilience because it offers a structured way to assess how governments anticipate, respond to, and recover from complex challenges. The framework distinguishes between analytical, operational, and political capacities across individual, organisational, and systemic levels, allowing for a nuanced understanding of institutional strengths and gaps. Systemic policy capacity, in particular, is essential for promoting cohesion, wellbeing, and resilience, as it encompasses the broader institutional norms, governance structures, and inter-organisational networks that enable coordinated action and long-term planning. In times of crisis—whether environmental, economic, or social—systemic capacity determines whether institutions can act decisively, inclusively, and adaptively.

Strong systemic capacity supports inclusive decision-making, fosters trust between government and society, and enables cross-sector collaboration, all of which are critical for social cohesion. It also enhances a society's ability to maintain wellbeing by ensuring continuity of essential services and equitable distribution of resources under stress. Furthermore, it underpins resilience by embedding adaptive learning, feedback mechanisms, and institutional memory into policymaking processes. In contrast, weak systemic capacity leads to fragmented responses, institutional silos, and public distrust. Applying Wu et al.'s framework allows analysts

and policymakers to identify where systemic reforms are needed to strengthen institutional resilience and, in turn, support a more cohesive, well, and resilient society.

5.3.2 POLICY (IN)CAPACITY AS A DETERMINANT OF NON-MATERIALIST RESILIENCE

Policy (in)capacity is a viable framework through which to appraise the themes of non-materialist resilience. Presented in Figure 3, this encompasses political, operational and analytical policy capacity at an individual, organisational and systemic level.

As such, non-materialist resilience largely encompasses institutional resilience, as trust in government and civil institutions, underpinned by their robustness, is critical to enable non-materialist resilience. Much of this discussion draws upon the work of Florian Jehn[74] and Walter Scheidel,[75] who argue robust democratic, participatory institutions are critical to enabling a more resilient society.

For example, in his analysis of historical case studies and surrounding literature, Jehn found that societies with greater inclusivity and participation managed to adapt more effectively to climatic challenges, experiencing fewer adverse social changes, such as population decline.[76] He attributes this adaptability to the flexibility inherent in participatory political systems, which allows for more effective responses to environmental and societal hazards. This capacity to adapt through participatory governance reflects characteristics of the 'Nordic model',[77] which emphasises the need to ameliorate power asymmetries and knowledge inequity in decision-making to generate long-term systemic resilience in societies.[78]

Likewise, Scheidel takes a historical approach to understanding economic inequality and its reduction. In his work, he identifies four primary forces—mass mobilisation warfare, transformative revolutions, state failures, and lethal pandemics—that have historically led to significant decreases in inequality.[79] Scheidel suggests that violent shocks have been the most effective means of reducing economic disparities over millennia. In this sense, the recover and adapt stages of Igor Linkov's model can be catalysed by social cohesion and collaboration in the recovery from shocks and stresses.

Turchin & Hoyer also through Structural Demographic Theory emphasise the relation between elites, state capacity, and the public; although the exact predictability and record of

[74] Florian U. Jehn. *Participation, Inclusion, Democracy, and Resilience*. Aug. 2023. URL: https://florianjehn.github.io/Societal_Collapse/2023-08-16-democracy_and_resilience/.

[75] Walter Scheidel. *The Great Leveler: Violence and the History of Inequality from the Stone Age to the Twenty-First Century*. Princeton: Princeton University Press, Dec. 2018. ISBN: 978-0-691-18431-9. DOI: 10.23943/9780691184319. URL: https://www.degruyter.com/document/doi/10.23943/9780691184319/html (visited on 06/05/2025).

[76] Jehn, *Participation, Inclusion, Democracy, and Resilience*.

[77] Nina Witoszek. *Sustainable Modernity: The Nordic Model and Beyond*. eng. Routledge Studies in Sustainability Series. Milton: Taylor & Francis Group, 2018. ISBN: 978-0-367-66683-5 978-1-351-76563-3.

[78] Nikolai Brandal, Øivind Bratberg, and Dag Einar Thorsen. *The Nordic model of social democracy*. eng. Basingstoke: Palgrave Macmillan, 2013. ISBN: 978-1-137-01326-2.

[79] Scheidel, *The Great Leveler*.

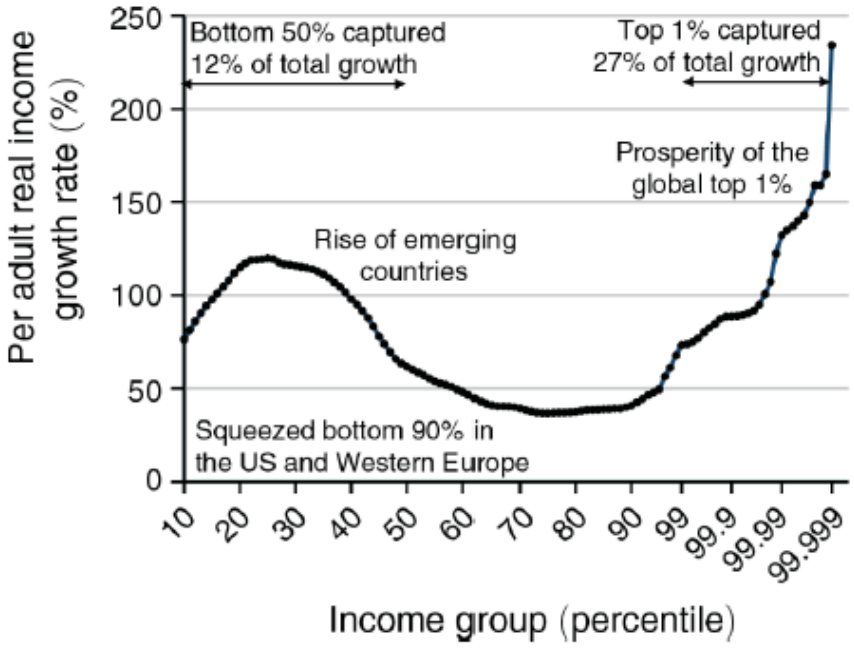

FIGURE 6: ELEPHANT CURVE GRAPH[83]

this framework can be qualified and critiqued, it can also be augmented by considerations of more traditional concerns relating to aforementioned inequalities, such as when drawing from Oana-Maria Georgescu's analysis on this.[80] These underscore, as Turchin & Hoyer also argue, how inclusive institutions of the kind most advanced with the Nordic model,[81] can serve as a model for how to bridge these factors resolutely in the face of their compounding tensions. The success of Finland[82] when transitioning from lower tech to higher tech economy, without losing employment, is highly instructive here (and for later discussions of how a mission-oriented approach might replicate such effective policymaking: see 'Research Development' section).

5.3.3 THE EROSION OF INSTITUTIONAL RESILIENCE OVER TIME

However, since the end of World War II, and the emergence of global free trade and globalisation, principles of neoliberalism and comparative advantage have become mainstream economic doctrine, underpinned by the principles of the 'Washington Consensus.' This argues na-

[80] Oana-Maria Georgescu. "The structural-demographic theory revisited: An empirical test for industrialized societies". en. In: *PLOS ONE* 18.11 (Nov. 2023). Ed. by Pranab Kumar Das, e0287912. ISSN: 1932-6203. DOI: 10.1371/journal.pone.0287912. URL: https://dx.plos.org/10.1371/journal.pone.0287912 (visited on 06/05/2025).

[81] Peter Turchin and Daniel Hoyer. *Empirically Testing and Refining Structural Demographic Theory: A Methodological Guide*. June 2023. DOI: 10.31235/osf.io/yrqw5. URL: https://osf.io/yrqw5 (visited on 06/05/2025).

[82] European Commission. *Finland's road to prosperity*. Tech. rep. European Commission, June 2006. URL: https://cordis.europa.eu/article/id/25919-finlands-road-to-prosperity.

[83] Facundo Alvaredo et al. "The Elephant Curve of Global Inequality and Growth". en. In: *AEA Papers and Proceedings* 108 (May 2018), pp. 103–108. ISSN: 2574-0768, 2574-0776. DOI: 10.1257/pandp.20181073. URL:

tions should maximise the economic activities they're the most efficient at, and outsource inefficient economic activities to other countries.[84]

While this has led to a momentous rise in global GDP, and rising living standards for the global poor, it has led to deindustrialisation and economic inequality in developed nations. This is embodied in the 'elephant curve' of global economic growth (see Figure 6).[85]

This has exacerbated an erosion of social cohesion and resilience,[86] which as Igor Linkov suggests, undermines social resilience. Likewise, the policy capacity framework in Figure 3 would frame this as an erosion of systemic political and operational policy capacity, because an erosion of trust in institutions, driven by the economic 'hollowing out' of communities, is accompanied by a loss of social cohesion.

5.3.4 DEMOCRATIC TRANSPARENCY

There has been a growing scepticism towards democratic institutions' legitimacy and intent, which is especially driven by concerns around corruption and malpractice in public administration. This undermines trust in government, which is a lapse of systemic policy capacity.

Democratic governance requires strong deliberative and participatory processes that enable transparency and critique of government institutions.[87] To bolster democratic transparency, governments must engage in collaborative governance and 'bridging leadership' through robust multi-stakeholder co-design and collaboration.[88]

Importantly, governments play a key role in promoting inclusion in collaborative governance, particularly through the 'opportunity structure'—being the design of deliberative processes.[89] Furthermore, Helen Sullivan underscores the need for governments to consider the

https://pubs.aeaweb.org/doi/10.1257/pandp.20181073 (visited on 06/05/2025).

[84] Karl Aiginger and Dani Rodrik. "Rebirth of Industrial Policy and an Agenda for the Twenty-First Century". en. In: *Journal of Industry, Competition and Trade* 20.2 (June 2020), pp. 189–207. ISSN: 1566-1679, 1573-7012. DOI: 10.1007/s10842-019-00322-3. URL: http://link.springer.com/10.1007/s10842-019-00322-3 (visited on 06/05/2025).

[85] Alvaredo et al., "The Elephant Curve of Global Inequality and Growth".

[86] Julia C. Becker, Lea Hartwich, and S. Alexander Haslam. "Neoliberalism can reduce well□being by promoting a sense of social disconnection, competition, and loneliness". en. In: *British Journal of Social Psychology* 60.3 (July 2021), pp. 947–965. ISSN: 0144-6665, 2044-8309. DOI: 10.1111/bjso.12438. URL: https://bpspsychub.onlinelibrary.wiley.com/doi/10.1111/bjso.12438 (visited on 06/05/2025).

[87] Paul Cairney. "Chapter 3: Power and Public Policy". In: *Understanding Public Policy: Theory and Issues*. Palgrave Macmillan.

[88] Sonia M. Ospina. "Collective Leadership and Context in Public Administration: Bridging Public Leadership Research and Leadership Studies". en. In: *Public Administration Review* 77.2 (Mar. 2017), pp. 275–287. ISSN: 0033-3352, 1540-6210. DOI: 10.1111/puar.12706. URL: https://onlinelibrary.wiley.com/doi/10.1111/puar.12706 (visited on 06/05/2025).

[89] Christopher Ansell et al. "Understanding inclusion in collaborative governance: a mixed methods approach". en. In: *Policy and Society* 39.4 (Oct. 2020), pp. 570–591. ISSN: 1449-4035, 1839-3373. DOI: 10.1080/14494035.2020.1785726. URL: https://academic.oup.com/policyandsociety/article/39/4/570/6404010 (visited on 06/05/2025).

FIGURE 7: PHOTO OF OCCUPY WALL STREET PROTESTS, A DEMONSTRATION OF ERODING TRUST IN GOVERNMENT

'spatial domain' of collaborative governance, being "what shape collaboration takes" for participating actors.[90] Likewise, Jacob Torfing emphasises the need for 'interactive democracy' between government and non-government stakeholders to build trust and tailored feedback loops between the diverse societal stakeholders and the public sector. This demonstrates aspects of 'pluricentric coordination—coordination between multiple stakeholders at different scales with both complementary and competing interests.[91]

In this context, the public sector can be a strong convening stakeholder with the capacity to 'activate' and 'enable' diverse and even competing non-government stakeholders, including in the civil society sector. Governments doing this effectively can "bring multiple stakeholders together for a common end in a situation of interdependence."[92]

Therefore, democratic transparency can largely be seen as a mix of upstream and downstream processes.[93] Upstream deliberation includes the development of policy and legislation in the executive and legislature, often influenced by upstream policy actors such as parliamentary committees and lobbyists. Downstream deliberation includes participatory instruments such as citizens' assemblies, focus group discussions, and informal community consultation.

John Boswell indicates the increasing skew towards upstream deliberation in policymaking, often manifesting in the form of perverse influence from lobbyists and special interest groups.[94] When upstream deliberation is untransparent, it promotes corruption and conflicts of interest in sound policymaking, resulting in erosion of trust in institutions from the polity. This erosion of trust undermines systemic policy capacity to address complex issues, as a lack of trust in government jeopardises the ability to generate an authorising environment among society-at-large to correspond with government agendas.[95]

This can create populist sentiments among the polity, leading to the rise of populist leaders who disregard or even denigrate evidence-based policymaking (see 'Epistemic Institutions' section). In this sense, there is a strong connection between society and government institutions, and there is a feedback loop between the sentiments of these groups. This is often termed sociological institutionalism.[96]

[90] Helen Sullivan. "A framework for analysing collaboration: Actors, collaborative domains, and public policy elements". In: *Collaboration and Public Policy: Agency in the Pursuit of Public Purpose*. Ed. by Helen Sullivan. 2022.

[91] Jacob Torfing. *Rethinking public governance*. Rethinking political science and international studies. Cheltenham, UK ; Northampton, MA, USA: Edward Elgar Publishing, 2023. ISBN: 978-1-78990-976-0.

[92] Lester M. Salamon. *The Tools of Government: A Guide to New Governance*. Oxford, New York: Oxford University Press, Mar. 2002. ISBN: 978-0-19-513665-4.

[93] John Boswell. "Deliberating Downstream: Countering Democratic Distortions in the Policy Process". en. In: *Perspectives on Politics* 14.3 (Sept. 2016), pp. 724–737. ISSN: 1537-5927, 1541-0986. DOI: 10.1017/S1537592716001146. URL: https://www.cambridge.org/core/product/identifier/S1537592716001146/type/journal_article (visited on 06/05/2025).

[94] Boswell, "Deliberating Downstream".

[95] Michael Cox. *Understanding the Global Rise of Populism*. Tech. rep. London School of Economics and Political Science, Feb. 2018. URL: https://www.lse.ac.uk/ideas/Assets/Documents/updates/LSE-IDEAS-Understanding-Global-Rise-of-Populism.pdf..

[96] André Lecours, ed. *New Institutionalism: Theory and Analysis*. University of Toronto Press, Dec. 2005. ISBN:

In this context, where there is a lack of clear downstream deliberation with the polity, it undermines trust. As per Igor Linkov's resilience matrix, this undermines social resilience in the plan/prepare stage of resilience, which represents a degradation of systemic operational and political policy capacity; when trust in institutions is eroded, leading to doubts about their legitimacy in times of emergency (see 'Epistemic Institutions' section).

Traditional institutionalism argues the typical institutional instruments such as the judiciary, the legislature, and the executive should be deliberate in a way that responds to constituents' concerns.[97] According to traditional institutionalism, the inability for institutions to perform effective deliberation and participation will result in discontent with government institutions, leading to election losses.

However, this theory is challenged by discourses of new institutionalism - which critiques traditional institutionalism as too theoretical, and not appreciative of the reality of political influences and ideological concerns in policymaking.[98] Rather, discourses such as historical institutionalism highlight the role of ideological inertia overriding rational, evidence-based decision making, and normative institutionalism highlights the role of norms and processes as more important than deliberative engagement with the community-at-large.[99] Likewise, rational choice institutionalism argues political actors are more motivated by their own political gain and influence in decision making compared to responding to the needs of constituents.

Hence, the influence of new institutionalist governance methods undermines traditional assumptions of democracy, and exacerbates upstream deliberation at the expense of participatory downstream deliberation. This adversely affects the transparency of democratic institutions, and therefore, overall trust in institutions by the polity. This undermines social resilience in the prepare/plan stages of resilience, as a lack of trust in institutions by the polity results in institutions being perceived as illegitimate and worthy of mistrust.

Furthermore, this erosion of trust is undermined by power asymmetries in governance, instead of equitable governance based on participatory design and implementation.[100] Power asymmetries are the result of powerful actors framing policy issues and discussions, therefore influencing the development of policy solutions, particularly through perverse 'upstream'

978-1-4426-7763-0. DOI: 10.3138/9781442677630. URL: https://www.degruyter.com/document/doi/10.3138/9781442677630/html (visited on 06/05/2025).

[97] Robert Leach. *The politics companion*. eng. Palgrave student companions - your course ... one source. Houndmills, Basingstoke, Hampshire New York, N.Y: Palgrave Macmillan, 2008. ISBN: 978-0-230-51790-5.

[98] B Guy Peters. "Institutional Theory: Problems and Prospects". In: *SSOAR* (2000). URL: https://nbn-resolving.org/urn:nbn:de:0168-ssoar-246573.

[99] Ian Greener. "The Potential of Path Dependence in Political Studies". en. In: *Politics* 25.1 (Feb. 2005), pp. 62–72. ISSN: 0263-3957, 1467-9256. DOI: 10.1111/j.1467-9256.2005.00230.x. URL: https://journals.sagepub.com/doi/10.1111/j.1467-9256.2005.00230.x (visited on 06/05/2025).

[100] Richard E. Matland. "Synthesizing the Implementation Literature: The Ambiguity-Conflict Model of Policy Implementation". en. In: *Journal of Public Administration Research and Theory* 5.2 (Apr. 1995), pp. 145–174. ISSN: 1477-9803. DOI: 10.1093/oxfordjournals.jpart.a037242. URL: https://academic.oup.com/jpart/article/5/2/145/880350/Synthesizing-the-Implementation-Literature-The (visited on 06/05/2025).

influences.[101] This is because policy agendas are established by competing stakeholder advocacy, and the most powerful advocates are 'issue drivers' for policymakers.[102] The influence of 'issue drivers' determines what moves from the 'agenda universe' to the 'institutional' and 'decision' agenda.[103] Examples include the perverse role of fossil fuel lobbyists in influencing international and national climate change policy, ranging from overemphasising the need for 'transitional' fuels like natural gas, or largely unproven technologies such as Carbon Capture & Storage (CC&S), where evidence-based climate policy would recommend against an overdependence on these technologies.[104]

It's this reality that influences the ability to blend organisational and systemic policy capacity, and therefore, govern complex issues in an effective way. This gives reason for the polity to question disciplinary governmentality, and therefore undermines trust in institutions. In turn, this challenges the continued role of epistemic institutions in addressing complex policy challenges.

5.3.5 EPISTEMIC INSTITUTIONS

Strong epistemic institutions are a necessary characteristic of institutional resilience; as they help enable trust in government and well-tailored, evidence-based policymaking. Key indicators for the robustness of epistemic institutions include transparency of policymaking processes, the extent of relevant stakeholder engagement, external & internal accountability mechanisms, and independence in empirical data gathering and analysis.

Increasingly, government institutions' organisational policy capacity is being undermined by mistrust in institutions, which is a lapse in systemic policy capacity. Stokey & Zeckhauser argue for a dependence on technocratic empiricism as the basis for evidence-based policymaking, with little consideration for interpretivist, deliberative insights as part of evidence-based policymaking.[105] However, this ignores the socio-political reality of complex policymaking. Meltzer & Schwartz argue the need for deliberative, participatory methods as essential

[101] Francesca Gains and Karen Clarke. "Constructing delivery: Implementation as an interpretive process". en. In: *Critical Policy Studies* 1.2 (June 2007), pp. 133–138. ISSN: 1946-0171, 1946-018X. DOI: 10.1080/19460171.2007.9518514. URL: http://www.tandfonline.com/doi/abs/10.1080/19460171.2007.9518514 (visited on 06/05/2025).

[102] "Chapter 6: Policy instruments". In: *The Australian policy handbook: A practical guide to the policymaking process*. Routledge, 2022, pp. 81–90. ISBN: 1-00-335199-9. URL: https://doi.org/10.4324/9781003351993.

[103] Frank Fischer and Gerald J. Miller, eds. *Handbook of Public Policy Analysis: Theory, Politics, and Methods*. en. 0th ed. Routledge, Sept. 2017. ISBN: 978-1-315-09319-2. DOI: 10.4324/9781315093192. URL: https://www.taylorfrancis.com/books/9781351564373 (visited on 06/05/2025).

[104] Edward T. Walker and Andrew Malmuth. "The natural gas industry, the Republican Party, and state preemption of local building decarbonization". en. In: *npj Climate Action* 3.1 (Nov. 2024), p. 98. ISSN: 2731-9814. DOI: 10.1038/s44168-024-00176-4. URL: https://www.nature.com/articles/s44168-024-00176-4 (visited on 06/05/2025).

[105] Edith Stokey and Richard Zeckhauser. *A primer for policy analysis*. eng. New York: Norton, 1978. ISBN: 978-0-393-09098-7 978-0-393-05688-4.

FIGURE 8: PHOTO OF DR. ANTHONY FAUCI, BEING OVERLOOKED BY PRESIDENT DONALD TRUMP, DURING A COVID-19 PRESS CONFERENCE DEMONSTRATING THE CONTENTION BETWEEN POLITICS AND POLICY

for epistemic institutions to integrate in evidence-based policymaking.[106] Literature suggests that policymaking cannot and should not be value free, or a purely technical exercise, hence legitimising a space for politics in epistemic policymaking.[107]

Good governance is the ability to synergise organisational and systemic policy capacity. Even if organisational policy capacity is strong, if institutions are not trusted, it undermines systemic policy capacity. In low-trust societies, it is difficult for citizens to trust epistemic institutions, particularly given the more technocratic nature of these types of institutions.[108]

The rise of populism has resonated with an increasing mistrust in epistemic institutions. Populists provide easy solutions to complex problems, and scapegoat established institutions as causes of policy inaction and social ailments. Terms such as 'drain the swamp' and MAGA (Make America Great Again) demonstrate aspects of policy by narrative.[109] This involves the use of policy framing as a tool to drive policy agendas and change the nature of systemic policy capacity towards complex problems, with scapegoating of epistemic institutions being a com-

[106] Rachel Meltzer and Alex Schwartz. *Policy Analysis as Problem Solving: A Flexible and Evidence-Based Framework*. en. 1st ed. 1 Edition. | New York : Taylor and Francis, [2019]: Routledge, Dec. 2018. ISBN: 978-1-315-20967-8. DOI: 10.4324/9781315209678. URL: https://www.taylorfrancis.com/books/9781351807364 (visited on 06/05/2025).

[107] Herbert Gottweis. "Rhetoric in policy making: Between logos, ethos, and pathos". In: *Handbook of Public Policy Analysis*. 1st Edition. Routledge, Sept. 2017, pp. 263–276. URL: https://doi.org/10.4324/9781315093192.

[108] Václav Št□tka et al. "Have people 'had enough of experts'? The impact of populism and pandemic misinformation on institutional trust in comparative perspective". In: *Information, Communication & Society* 0.0 (2024). Publisher: Routledge _eprint: https://doi.org/10.1080/1369118X.2024.2413121, pp. 1–22. DOI: 10.1080/1369118X.2024.2413121. URL: https://doi.org/10.1080/1369118X.2024.2413121.

[109] "Chapter 6: Policy instruments".

mon feature.

For example, the National Institute of Allergy and Infectious Diseases, and its leader, Dr Anthony Fauci, were denigrated and delegitimised by President Donald Trump and his populist constituents during the COVID-19 pandemic.[110] Similarly, institutions such as the UN Framework Convention on Climate Change (UNFCCC) have come under critique and delegitimisation from populist politicians and polities across the world. Climate change policy is often seen as detached and elitist, even if its impacts are very immediate and local.[111]

In large part, media bias and media market concentration has substantially influenced the perspectives of politically conservative polities.[112] Most notably, Rupert Murdoch's NewsCorp has dominated Western, English speaking media for the last 40 years, framing complex policy issues in simple, binary and often adversarial terms.[113] This confluence between social norms and political messaging, mediated by the media, reflects notions of sociological institutionalism.

There are also debates around technocracy vs. democracy, and the role of epistemic institutions in the context of this dichotomy. Some literature argues evidence can take the form of technocratic "authoritative choice".[114] This argues that a focus on empiricism should take priority over deliberative processes, as affected policy stakeholders are too self-interested and naive to inform public policy in the name of the public interest.

Alternatively, other literature argues that deliberative processes are a necessary form of evidence rather than purely technical empiricism, as they enable a 'social construction' of problems, and therefore, an appropriate 'social construction' of solutions to complex policy issues.[115]

As such, evidence-based policy is being replaced by discussion with evidence-informed policy.[116] In fact, Richard French argues researchers must "reject naïve but prevalent assumptions

[110] Paul E. Rutledge. "Trump, COVID-19, and the War on Expertise". en. In: *The American Review of Public Administration* 50.6-7 (Aug. 2020), pp. 505–511. ISSN: 0275-0740, 1552-3357. DOI: 10.1177/0275074020941683. URL: https://journals.sagepub.com/doi/10.1177/0275074020941683 (visited on 06/05/2025).

[111] Robert O. Keohane. "The Global Politics of Climate Change: Challenge for Political Science". en. In: *Political Science and Politics* 48.1 (Jan. 2015), pp. 19–26. ISSN: 1049-0965, 1537-5935. DOI: 10.1017/S1049096514001541. URL: https://www.cambridge.org/core/product/identifier/S1049096514001541/type/journal_article (visited on 06/05/2025).

[112] Art Silverblatt. "Media as Social Institution". en. In: *American Behavioral Scientist* 48.1 (Sept. 2004), pp. 35–41. ISSN: 0002-7642, 1552-3381. DOI: 10.1177/0002764204267249. URL: https://journals.sagepub.com/doi/10.1177/0002764204267249 (visited on 06/05/2025).

[113] Luca Manucci. "Populism and the Media". In: *The Oxford Handbook of Populism*. _eprint: https://academic.oup.com/book/0/chapter/211654095/chapter-ag-pdf/44599379/book_27977_section_211654095.ag.pdf. Oxford University Press, Oct. 2017, pp. 467–492. ISBN: 978-0-19-880356-0. DOI: 10.1093/oxfordhb/9780198803560.013.17. URL: https://doi.org/10.1093/oxfordhb/9780198803560.013.17.

[114] Hal K Colebatch. "Policy, models, and the construction of governing". In: *The work of policy: An international survey* (2006). Publisher: Lexington Books Lanham, MD, pp. 3–19.

[115] Colebatch, "Policy, models, and the construction of governing".

[116] Heather E. Douglas. "The Moral Responsibilities of Scientists (Tensions between Autonomy and Responsi-

about the level of analytical rationality in government", bringing into question the role that organisational analytical capacity can play in formulating policies for long-term resilience and wellbeing.[117]

Meanwhile, evidence must balance three 'lenses' in evidence-based policymaking: systematic scientific evidence, qualitative and managerial consultative evidence, and political nous.[118] However, different policy domains and different political administrations often imbalance these evidence methods, leading to misinformed policies or a skewed framing of policies.[119]

In light of this, Meltzer & Schwartz argue for the need to have a flexible use of evidence in policymaking to accommodate the political realities of policymaking, which is particularly important amidst the rise of populism and political polarisation. This brings the role of epistemic institutions into question, and to what extent they should depend on pure empiricism without a consideration of normative social values.[120] Empirical findings and technocratic implementation are never values-free, and always intersect with the socio-cultural and socio-political norms.

From a resilience standpoint, Igor Linkov argues it is necessary to have a robust blend of information, cognitive, and social resilience, that depends not just on top-down organisational analytical policy capacity but a proper consideration of social, cultural, and political values that permeate society and enable or disable resilience. This bridges the Plan/Prepare stage all the way to the Adapt stage of Linkov's framework.

As such, while empiricism and epistemic institutions are important, they must be accountable via deliberative processes. This includes three lines of accountability – accountability to the scientific community, to the policy decision makers, and to the general public.[121] It is important to note that strong democracies, typically guided by very democratic and deliberative policy cultures, had more success in reducing excess deaths in the COVID-19 pandemic than more authoritarian regimes. In particular, stronger deliberative governance was an influential

bility)'". In: *American Philosophical Quarterly* 40.1 (2003), pp. 59–68. URL: http://www.jstor.org/stable/20010097; Richard D French. "Is it time to give up on evidence-based policy? Four answers". In: *Policy & Politics* 47.1 (Jan. 2019), pp. 151–168. ISSN: 0305-5736, 1470-8442. DOI: 10.1332/030557318X15333033508220. URL: https://bristoluniversitypressdigital.com/view/journals/pp/47/1/article-p151.xml (visited on 06/05/2025).

[117] French, "Is it time to give up on evidence-based policy?"

[118] Brian W. Head. "Three Lenses of Evidence Based Policy". en. In: *Australian Journal of Public Administration* 67.1 (Mar. 2008), pp. 1–11. ISSN: 0313-6647, 1467-8500. DOI: 10.1111/j.1467-8500.2007.00564.x. URL: https://onlinelibrary.wiley.com/doi/10.1111/j.1467-8500.2007.00564.x (visited on 06/05/2025).

[119] Carol Hirschon Weiss, Erin Murphy-Graham, and Sarah Birkeland. "An Alternate Route to Policy Influence: How Evaluations Affect D.A.R.E.". en. In: *American Journal of Evaluation* 26.1 (Mar. 2005), pp. 12–30. ISSN: 1098-2140, 1557-0878. DOI: 10.1177/1098214004273337. URL: https://journals.sagepub.com/doi/10.1177/1098214004273337 (visited on 06/05/2025).

[120] Marta Sienkiewicz and David Mair. "Against the Science–Policy Binary Separation". en. In: *Science for Policy Handbook*. Elsevier, 2020, pp. 2–13. ISBN: 978-0-12-822596-7. DOI: 10.1016/B978-0-12-822596-7.00001-2. URL: https://linkinghub.elsevier.com/retrieve/pii/B9780128225967000012 (visited on 06/05/2025).

[121] Douglas, "The Moral Responsibilities of Scientists (Tensions between Autonomy and Responsibility)"'.

contributor to fewer excess deaths. This is largely because more democratic societies have more deliberative governance, and deliberative governance results in greater trust in institutions and government.[122]

This observation demonstrates the role of social trust & cohesion in ensuring long-term resilience among society, including a blend of organisational and systemic policy capacity.

5.3.6 SOCIAL TRUST

Indicators for social trust include the extent of civic engagement in society and trust in public institutions. Frameworks exploring these indicators include the OECD Trust Framework, the Social Progress Index, and the Edelman Trust Barometer.

A large part of achieving social trust among societal stakeholders, and between society and government is collective leadership and bridging civil society and government.[123] As previously stated, COVID-19 demonstrated the connection between democratic and deliberative governance and reducing excess deaths during the pandemic, largely due to greater trust in institutions and therefore, more willingness to comply with government mandates.[124] The resilience matrix by Linkov would argue this demonstrates social resilience across all stages of resilience, but especially the 'absorb' stage.

Civil society represents the concerns of communities within which they operate, acting as an important conduit between the community and the public sector, and between societal stakeholders[125] and is, therefore, integral to effective systemic policy capacity. This is particularly because it plays an important democratic role in holding hegemonic statist powers to account, and promoting new, disruptive policy discussions relevant to the communities they work within, as proposed by Antonio Gramsci.[126] Advocacy from civil society also demonstrates aspects of 'networked governance' and multi-stakeholder polycentric governance, as argued by Elinor Ostrom. Likewise, Linkov's framework presents this as social resilience, whereby the

[122] Vageesh Jain, Jonathan Clarke, and Thomas Beaney. "Association between democratic governance and excess mortality during the COVID-19 pandemic: an observational study". en. In: *Journal of Epidemiology and Community Health* 76.10 (Oct. 2022), pp. 853–860. ISSN: 0143-005X, 1470-2738. DOI: 10.1136/jech-2022-218920. URL: https://jech.bmj.com/lookup/doi/10.1136/jech-2022-218920 (visited on 06/05/2025).

[123] Sonia Ospina and Erica Foldy. "Building bridges from the margins: The work of leadership in social change organizations". en. In: *The Leadership Quarterly* 21.2 (Apr. 2010), pp. 292–307. ISSN: 10489843. DOI: 10.1016/j.leaqua.2010.01.008. URL: https://linkinghub.elsevier.com/retrieve/pii/S1048984310000275 (visited on 06/05/2025).

[124] Jain, Clarke, and Beaney, "Association between democratic governance and excess mortality during the COVID-19 pandemic".

[125] Rupert Graf Strachwitz. "Civil Society as an Agent of Change". In: *Knowledge and Civil Society*. Ed. by Johannes Glückler, Heinz-Dieter Meyer, and Laura Suarsana. Cham: Springer International Publishing, 2022, pp. 43–56. ISBN: 978-3-030-71147-4. DOI: 10.1007/978-3-030-71147-4_3. URL: https://doi.org/10.1007/978-3-030-71147-4_3.

[126] Souvik Lal Chakraborty. "Gramsci's Idea of Civil Society". In: *International Journal of Research in Humanities and Social Studies* 3.6 (2016), pp. 19–27. URL: https://www.ijrhss.org/pdf/v3-i6/4.pdf.

social authorising environment enables or disables the ability to achieve long-term systemic resilience.

The role of social authorising environments in achieving resilience reflects notions of socialist governmentality, and overcoming excessive disciplinary governmentality that undermines social trust in institutions. John Dryzek complements this sentiment – advocating for citizens to be actively involved in how the use of research in policymaking is governed and managed.[127] Davies & Horst also advocate for the democratisation of science and expert decision making as a means of reconciling deliberation and expert advice.[128] Davies & Horst argue for methods such as 'consensus conferences' and 'citizen's juries', congregating a diverse range of stakeholders to deliberatively seek insights and input into policymaking.

Participatory evidence making use can address several barriers to evidence. This includes overcoming the notion that scientific expertise and policymaking are of 'two communities' incongruent with each other, and that science does not understand politics and policymaking.[129] Participatory evidence making can also facilitate better 'evidence informed policymaking', in the context of evidence based policymaking being deemed unrealistic and too technocratic.[130] It also enables stronger science communication—making the complexities of science and expert advice easier to understand, which has traditionally been a barrier to deliberative evidence making and evidence use.[131]

In this sense, institutions and society must reconsider their ability to regain trust between each other, which can be enabled through deliberative processes. This epitomises the idea of blending organisational and systemic policy capacity.

5.3.7 WELLBEING ECONOMICS

Kate Raworth's Doughnut Economics framework is essential for analysing the importance of wellbeing economics because it redefines progress beyond GDP, focusing on both human wellbeing and ecological sustainability. The framework visualises a safe and just space for humanity—between a social foundation that ensures basic needs and an ecological ceiling that respects planetary boundaries. This dual focus makes it especially relevant for assessing national re-

[127] John S. Dryzek. *Deliberative Democracy and Beyond: Liberals, Critics, Contestations*. en. 1st ed. Oxford University PressOxford, Jan. 2002. ISBN: 978-0-19-925043-1 978-0-19-171725-3. DOI: 10.1093/019925043X.001.0001. URL: https://academic.oup.com/book/3638 (visited on 06/05/2025).

[128] Catherine Althaus et al. *The Australian Policy Handbook: A Practical Guide to the Policymaking Process*. en. 7th ed. London: Routledge, Nov. 2022. ISBN: 978-1-003-35199-3. DOI: 10.4324/9781003351993. URL: https://www.taylorfrancis.com/books/9781003351993 (visited on 06/05/2025).

[129] Weiss, Murphy-Graham, and Birkeland, "An Alternate Route to Policy Influence".

[130] Weiss, Murphy-Graham, and Birkeland, "An Alternate Route to Policy Influence".

[131] Sandra M. Nutley, Isabel Walter, and Huw T.O. Davies. "One: Using evidence – introducing the issues". English. In: Bristol, UK: Policy Press, Mar. 2007, pp. 1–32. ISBN: 978-1-84742-232-3. DOI: 10.51952/9781847422323.ch001. URL: https://bristoluniversitypressdigital.com/view/book/9781847422323/ch001.xml.

silience, as it highlights how economic systems must balance social equity with environmental limits. In an era of climate crises, inequality, and systemic shocks, traditional economic models fail to capture the full picture of vulnerability and sustainability. The Doughnut framework encourages governments to design policies that foster inclusive, regenerative economies that are more robust in the face of external stressors. By centring wellbeing, it helps countries build resilience not just through economic growth, but through social cohesion, ecological health, and long-term sustainability. This makes it a vital tool for guiding nations toward more resilient and thriving futures.

THE LIMITATIONS OF GDP

The traditional reliance on GDP as the primary measure of economic success has increasingly come under scrutiny. Critics argue that GDP offers a narrow and parochial view, failing to reflect the complexities of human wellbeing and environmental sustainability. The singular focus on economic growth as an ultimate goal often neglects broader societal needs, such as equity and environmental health. This critique aligns with the sustainable development discourse, which advocates for balancing economic prosperity, social equity, and environmental sustainability.

WELLBEING ECONOMICS AND DOUGHNUT ECONOMICS

In response to the limitations of GDP, **wellbeing economics** has emerged as a critical framework. It prioritizes human and planetary wellbeing over economic growth. Kate Raworth's **Doughnut Economics Framework** is a prominent example of this paradigm shift, integrating **Rockström's planetary boundaries** with social foundations to define the 'safe and just space' where humanity can thrive.[132] This approach encapsulates the need to simultaneously respect ecological limits and meet societal needs, offering a comprehensive model for a wellbeing economy (see Figure 2).

As argued by Marina Mazzucato "if we prioritise the economy's regenerative potential—that is, the ability to regenerate sources of value creation within both planetary boundaries and human and physical capital boundaries—it is useful to think in terms of a circular economy".[133] This implores policymakers and wellbeing economists to interrogate the interconnection between the circular economy and doughnut economics, and how these can nurture new institutions and collaborations between organisations to live within the planetary boundaries. Meanwhile, Kate Raworth posits that this requires investment in socio-environmental assets

[132] Tonia Warnecke. "Operationalizing the Doughnut Economy: An Institutional Perspective". en. In: *Journal of Economic Issues* 57.2 (Apr. 2023), pp. 643–653. ISSN: 0021-3624, 1946-326X. DOI: 10.1080/00213624.2023.2202570. URL: https://www.tandfonline.com/doi/full/10.1080/00213624.2023.2202570 (visited on 06/05/2025).

[133] Mazzucato, *Mission economy*.

such as food, housing, healthcare and even sovereign high-value add industries (see 'Research and Development' section).

MEASURING WELLBEING: FRAMEWORKS AND INDICATORS

Governments and organisations are increasingly adopting frameworks to operationalise wellbeing economics. The Australian Federal Treasury's Measuring What Matters framework exemplifies this effort.[134] It categorises wellbeing in five interconnected dimensions:

- **Healthy:** Ensuring access to physical and mental healthcare, information, and services.
- **Secure:** Promoting safety, financial stability, and housing access.
- **Sustainable:** Encouraging responsible resource use, environmental protection, and resilience building.
- **Cohesive:** Fostering community connections, diversity, and cultural belonging.
- **Prosperous:** Strengthening education, employment, and economic opportunities.

Equity and inclusion are cross-cutting principles within this framework, operationalised through 12 dimensions and 50 indicators designed to track progress over time. This approach reflects a shift toward metrics that address the multi-faceted nature of wellbeing. Achieving characteristics of the wellbeing economy is also instrumental to enabling social trust and the social resilience associated with it.[135] In turn, this promotes better social and cognitive resilience, as per Linkov's resilience matrix.

WELLBEING ECONOMY GOVERNMENTS AND ADVOCACY

The Wellbeing Economy Governments (WEGo) initiative highlights a growing governmental commitment to wellbeing. WEGo partners pursue shared ambitions to transition from growth-focused models to ones prioritising balanced sufficiency, equity, and sustainability.[136] The **Wellbeing Economy Alliance (WEAll)**, a leading advocacy group, reinforces this perspective, advocating for economies that centre human and planetary needs.[137] Similarly, Mason and Büchs

[134] Department of the Treasury. *Measuring what matters | Treasury.gov.au*. en. text. Publisher: Department of the Treasury. July 2023. URL: https://treasury.gov.au/policy-topics/measuring-what-matters (visited on 03/23/2025).

[135] Becker, Hartwich, and Haslam, "Neoliberalism can reduce well□being by promoting a sense of social disconnection, competition, and loneliness".

[136] Hayden, "The wellbeing economy in practice".

[137] Hoekstra, *Measuring the Wellbeing Economy: How to Go Beyond GDP*.

emphasise the importance of sufficiency and resilience in wellbeing-oriented frameworks, which relates to R&D and industrial policy.[138]

The transition to a wellbeing economy also intersects with subjective and interdisciplinary approaches. Mark Fabian highlights the role of complexity science, arguing that wellbeing should be understood as an emergent property of interconnected systems. This perspective recognises the non-linear dynamics of economic, social, and ecological processes, suggesting that wellbeing arises from their alignment rather than isolated interventions.[139]

Additionally, subjective wellbeing frameworks provide nuanced insights into individual and collective perceptions of quality of life. By integrating subjective perspectives, policymakers can account for diverse human experiences, ensuring that wellbeing measures are responsive to cultural, psychological, and contextual variations.[140]

RESEARCH & DEVELOPMENT

In light of global economic inequalities, and in response to supply chain fragilities exposed by COVID-19, global governments are subverting principles of the Washington Consensus by reshoring domestic R&D and manufacturing.[141] This is termed 'industrial policy', which involves governments taking a larger role in determining the trajectory and composition of their economies, rather than reverting to purely neoliberal and free market forces. Many economists have challenged the prevailing neoliberal economic orthodoxy, which rejected industrial policy for its past associations with protectionism, clientelism and economic inefficiency. Notable examples of industrial policy include the US Inflation Reduction Act (IRA), Australia's Future Made In Australia (FMIA) Act and the European Chips Act.

This relates industrial policy to wellbeing economics, as these industrial policies encourage the creation of high value-add economic activities that enhance social wellbeing, through employment and the economic multiplier effect, but also environmental sustainability, as these high value-add industries include net zero and circular economy industries. The Finnish miracle of the 20th Century in large part understood exactly these interplaying factors, and wisely invested in scaling them for the common good.[142] Ferrannini & others argue that since the 2008

[138] Naomi Mason and Milena Büchs. "Barriers to adopting wellbeing-economy narratives: comparing the Wellbeing Economy Alliance and Wellbeing Economy Governments". en. In: *Sustainability: Science, Practice and Policy* 19.1 (Dec. 2023), p. 2222624. ISSN: 1548-7733. DOI: 10.1080/15487733.2023.2222624. URL: https://www.tandfonline.com/doi/full/10.1080/15487733.2023.2222624 (visited on 06/05/2025).

[139] Fabian, *A theory of subjective wellbeing*.

[140] Marie J. C. Forgeard et al. "Doing the Right Thing: Measuring Well-Being for Public Policy". In: *International Journal of Wellbeing* 1.1 (Jan. 2011). ISSN: 11798602. DOI: 10.5502/ijw.v1i1.15. URL: http://www.internationaljournalofwellbeing.org/index.php/ijow/article/view/15 (visited on 06/05/2025).

[141] Andrea Coveri et al. "Supply chain contagion and the role of industrial policy". en. In: *Journal of Industrial and Business Economics* 47.3 (Sept. 2020), pp. 467–482. ISSN: 0391-2078, 1972-4977. DOI: 10.1007/s40812-020-00167-6. URL: https://link.springer.com/10.1007/s40812-020-00167-6 (visited on 06/05/2025).

[142] Commission, *Finland's road to prosperity*.

GFC, there has been much more critique towards neoliberal governmentality, which has historically led to "mis-investment in the non-tradable sector at the expense of growth-rich tradables" and has eroded the facilitation of long-run, inclusive and sustainable. prosperity[143] In contrast, Ferrannini et al. promote the role of industrial policy as promoting both environmental and social goals to enable long-term growth and prosperity. The resilience matrix by Linkov would argue this is critical to overcome the vacuum of social resilience created by neoliberal governmentality, as industrial policy creates more robust social and economic opportunities for communities, rather than the 'hollowed out' social economy generated by neoliberal policies.

This demonstrates principles of doughnut economics espoused by Kate Raworth, as industrial policy demonstrates a balance of social, economic and environmental prowess, particularly at a more localised level. This contrasts with traditional neoliberal governmentality, which ignores local economic growth and activity, instead focusing on traditional measures of GDP, irrespective of the localised wellbeing (dis)benefits or environmental consequences.[144]

Likewise, achieving robust R&D through industrial policy requires a healthy mix of:

Directionality. Setting a clear direction (narrow, defined priorities), backed with a high-level political and fiscal commitment that signals directions to industry and the economy. Mariana Mazzucato argues the need for a 'mission driven economy', where governments define clear direction for R&D and activate economic activity in pursuit of its R&D objectives. This contravenes principles of neoliberal doctrine, where governments were expected to 'steer', but not 'row' an economy.[145] However, industrial policy encourages governments to 'row' an economy and take a more proactive role in moving an economy in a particular direction, rather than simply relegating the direction of an economy to free-market forces. This must be underpinned by a comprehensive policy mix. In this sense, industrial policy shapes and creates markets to solve concrete societal challenges, rather than just fixing them.

Policy Mix. A comprehensive set of policy tools are necessary for a government-wide approach to support directional goals, including boosting innovation, supply-side coordination, helping firms get to scale and building demand. This includes procurement, grants, equity fi-

[143] Andrea Ferrannini et al. "Industrial policy for sustainable human development in the post-Covid19 era". en. In: *World Development* 137 (Jan. 2021), p. 105215. ISSN: 0305750X. DOI: 10.1016/j.worlddev.2020.105215. URL: https://linkinghub.elsevier.com/retrieve/pii/S0305750X20303429 (visited on 06/05/2025); David Bailey, Keith Cowling, and Phil Tomlinson, eds. *New perspectives on industrial policy for a modern Britain*. First edition. OCLC: ocn898926556. Oxford, United Kingdom: Oxford University Press, 2015. ISBN: 978-0-19-870620-5.

[144] Madeleine Wahlund and Teis Hansen. "Exploring alternative economic pathways: a comparison of foundational economy and Doughnut economics". en. In: *Sustainability: Science, Practice and Policy* 18.1 (Dec. 2022), pp. 171–186. ISSN: 1548-7733. DOI: 10.1080/15487733.2022.2030280. URL: https://www.tandfonline.com/doi/full/10.1080/15487733.2022.2030280 (visited on 06/05/2025).

[145] Mazzucato, *Mission economy*.

nance, debt finance, education and training, skilled migration, regulating demand and so forth. Table 4 demonstrates these types of policy mixes.

Governance. Convening ministers or departments at a high level to ensure alignment, providing a forum for engagement and leadership from industry itself, and building institutional capacity.[146] This demands a level of systems thinking and transdisciplinary analysis between different policy portfolios to achieve effective R&D through industrial policy, including the wellbeing benefits.[147]

Through applying effective directionality, policy mix and governance to R&D, governments can 'row' an economy towards productive high value-add industries that improve innovation and livelihoods while also improving the resilience of an economy to shocks and stresses, particularly in the context of supply chain vulnerability.[148] The framework of Igor Linkov would argue this enables resilience across all typologies, especially in the 'plan/prepare' stage, 'absorb' and 'adapt' stages.

Likewise, it is possible for robust industrial policy to 'crowd in' private capital investment, leading to localised wellbeing and economic growth, contrasting with common criticisms of industrial policy as 'crowding out' private capital. Once again, this reinforces that governments do not just need to 'steer' an economy, relegated to simply correcting market failures, but actually 'row' an economy in a productive, diversified direction.[149]

6 FRAMEWORK INTEGRATION AND SYNTHESIS

6.1 IGOR LINKOV'S MATRIX RELEVANCE

Linkov's resilience matrix focuses on physical, information, cognitive and social resilience, and the plan/prepare, absorb, recover and adapt stages.

1. **Physical Resilience:** the tangible aspects of a system, including infrastructure and hardware. It focuses on maintaining and restoring physical assets to ensure continuous operation during and after disruptive events.

[146] Chiara Criscuolo. *An industrial policy framework for OECD countries: Old debates, new perspectives.* en. OECD Science, Technology and Industry Policy Papers 127. Series: OECD Science, Technology and Industry Policy Papers Volume: 127. May 2022. DOI: 10.1787/0002217c-en. URL: https://www.oecd.org/en/publications/an-industrial-policy-framework-for-oecd-countries_0002217c-en.html (visited on 06/05/2025).

[147] Toby Phillips and Esther Koh. "Setting direction: A purposeful approach to modern industry policy, CPD discussion paper". In: *Centre for Policy Development* (2024). URL: https://cpd.org.au/wp-content/uploads/2024/04/Setting-Direction-A-purposeful-approach-to-modern-industry-policy-1.pdf.

[148] Ferrannini et al., "Industrial policy for sustainable human development in the post-Covid19 era".

[149] Mazzucato, *Mission economy*.

Boosting Innovation	
Public R&D expenditure	Funding to public organisations, universities and research institutes, for research contributing to industrial development priorities. This can include postgraduate loans and scholarships.
Innovation clusters	This approach bridges the gap between research and industry, and consists of industrial precincts of R&D centres that specialise in technology and innovation, and benefit from geographical proximity.
Supply-side Coordination	
Education and training	The enlarged and new industries will create jobs and therefore will require a focus and strategy on these sectors to develop and transform jobs and skills. This might look like particular subsidies, and new TAFE centres in regions.
Skilled migration	Attracting skilled migration in high-demand industries that will help drive R&D. Governments can create new visa programs tailored to priority R&D industries.
Getting to scale	
Start-up grants	Start-up grants can support a range of activities including proof-of-concept or demonstration projects, up to seed funding or initial investment rounds (at which point they overlap with the next category). In Australia ARENA fills this function for climate-related businesses, while in Germany, its High Tech Strategy includes an open, competitive project funding program set up to address the mission's challenge – in particular to answer the major unresolved questions in cancer research.
Investment capital	Many government schemes provide capital to new industries. These investments – such as loans, equity and venture capital – are intended to deliver a return to the government and may include 'capital recycling' (where the profit generated from your first investments are then reinvested in subsequent investments). We also count investment tax credits as a form of investment capital.
Economic subsidies	Subsidies that operate either on a per-unit basis (such as production or consumption subsidies) or on a contingent basis with a de-risking effect (such as a contract-for-difference) can help support the business case for new industries – closing any gap between market price and the cost of production, and giving investors confidence.
Building Demand	
Public procurement	Government procurement can contribute to enable a level playing field in markets, and can help to foster sustainable and inclusive growth.
Regulating demand	Regulatory reform can also be used to shift behaviour and support new industries. At a broad level (non-sector specific), good competition policy supports innovation. Sector-specific regulatory support can be fraught, as it risks a return to protectionism, but can be justified when required to make markets operate more efficiently.

TABLE 4: TYPES OF POLICY MIXES FOR RESILIENT, LONG-TERM INDUSTRIAL POLICY

2. **Information Resilience:** the creation, manipulation, sharing, and protection of data. This domain emphasises the importance of information flow and integrity, especially during crises when accurate data is crucial for decision-making.

3. **Cognitive Resilience:** the mental processes of individuals and groups, including perception, interpretation, and response to information. It highlights the capacity of stakeholders to understand and act upon information effectively during disruptions.

4. **Social Resilience:** the relationships, networks, and collaborative efforts among individuals and communities. This domain underscores the role of social structures in supporting collective action and recovery during adverse events.

Stages

1. **Prepare:** Activities aimed at anticipating potential disruptions and implementing measures to prevent or mitigate their impact.

2. **Absorb:** The capacity of a system to endure shocks without significant degradation of essential functions.

3. **Recover:** Processes that restore a system's functionality and performance after a disruption.

4. **Adapt:** Long-term adjustments and transformations that enhance a system's resilience against future disruptions.

By systematically evaluating each domain across these stages, the Resilience Matrix provides a comprehensive assessment of a system's strengths and vulnerabilities. This approach facilitates the identification of areas needing improvement and supports the development of strategies to bolster overall resilience. The matrix has been applied in various contexts—such as resilience and recovery of communities on the Rockaway Peninsula, New York, in the face of Hurricane Sandy.[151]

6.2 THREE HORIZONS FRAMEWORK

The Three Horizons framework (Figure 10) presents an approach to managing complex societal transformations by addressing dynamic, social, and generative complexities across interconnected scales. The framework distinguishes three horizons:

[150] Linkov et al., "Measurable Resilience for Actionable Policy".

[151] Cate Fox-Lent, Matthew E. Bates, and Igor Linkov. "A matrix approach to community resilience assessment: an illustrative case at Rockaway Peninsula". en. In: *Environment Systems and Decisions* 35.2 (June 2015), pp. 209–218. ISSN: 2194-5403, 2194-5411. DOI: 10.1007/s10669-015-9555-4. URL: http://link.springer.com/10.1007/s10669-015-9555-4 (visited on 06/05/2025).

[152] Sharpe et al., "Three horizons".

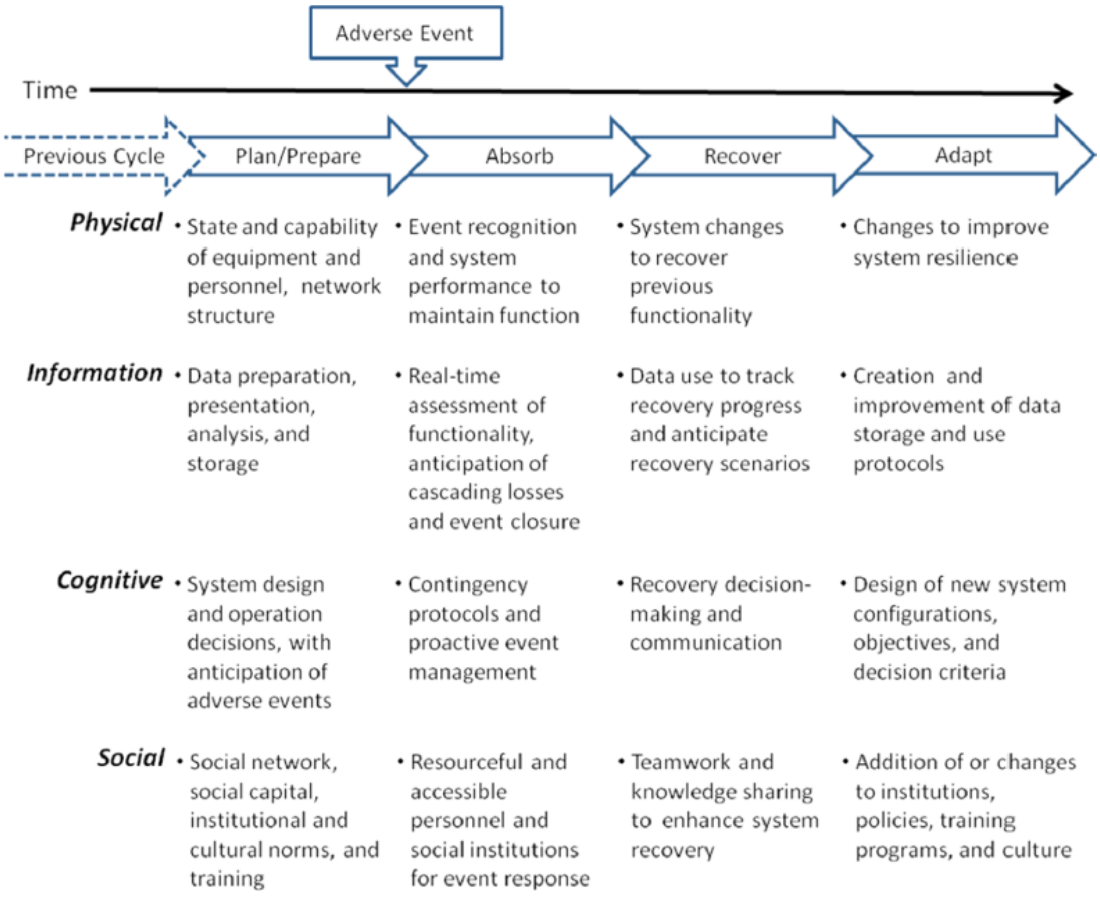

FIGURE 9: IGOR LINKOV'S RESILIENCE MATRIX[150]

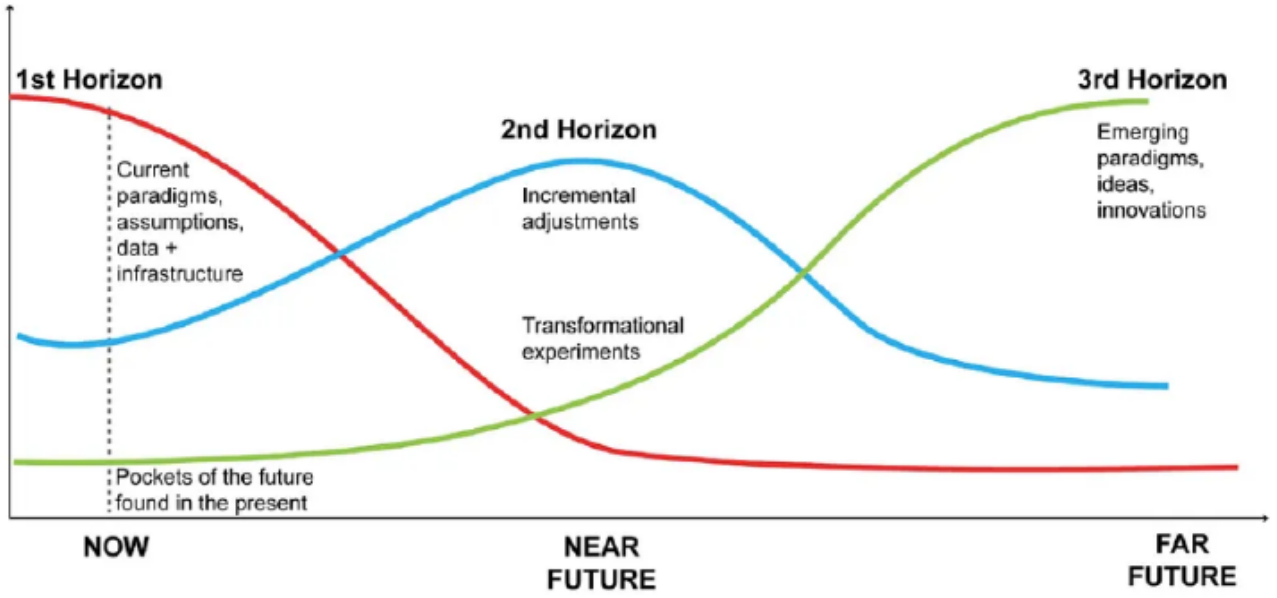

FIGURE 10: THE INTERACTING ELEMENTS OF THE 3 HORIZONS FRAMEWORK, INDICATING SHORT, MEDIUM AND LONG-TERM SHIFTS REQUIRED TO DRIVE RESILIENT, TRANSFORMATIVE CHANGE[152]

H1 (current business-as-usual). Often labelled the 'Manager's Mindset', is the entrenched perspective that must be overcome in the short-term to enable a stronger, more resilient medium to long term future, represented in H2 and H3 respectively.

H2 (transitional innovations). Often labelled the 'disruptor's mindset', in this horizon are the medium term shifts required to build foundations for the long-term transformations of H3. It is the transition between business-as-usual and the long-term resilient future.

H3 (emerging transformative patterns). Often labelled the 'visionary mindset', this is the resilient future that society should aim to define and work towards, and is built upon the foundations of H1 and H2 going through the trajectory presented in Figure 10.

The framework enables stakeholders to examine present concerns, explore future aspirations, identify inspiring current practices, evaluate ongoing innovations, and maintain essential features. While traditional forecasting and roadmapping work well in low-complexity situations,[153] the Three Horizons approach specifically addresses high-uncertainty scenarios where transformative changes are needed. This is further elaborated in Figure 9, which shows how 'pathways', such as the Three Horizons Framework, are useful in circumstances of high uncertainty.

Likewise, Figure 10 details each of the 3 horizons, looking at how they interact with each other in a processual manner.

The framework helps practitioners understand power dynamics in societal transformation, highlighting how new policies may threaten H1 actors while powerful incumbents can still suppress threatening innovations inherent in H2 and especially H3.[154]

However, it's also important to appreciate which factors can prevent transition between the horizons. This includes the factors of policy inaction defined by McConnell & t'Hart:[155]

Ideological Inaction: Inaction as a product of particular ideologies, that can entrap politicians and policy makers within a particular ideological frame of reference.

Calculated Inaction: Inaction driven by convictions and deliberated decision making, but often based on short-term priorities and bounded rationality.

Imposed Inaction: Inaction as pragmatic acceptance that requisite support will not be obtained.

[153] Ronald A. Halim, Jan H. Kwakkel, and Lóránt A. Tavasszy. "A scenario discovery study of the impact of uncertainties in the global container transport system on European ports". In: *Futures*. Modelling and Simulation in Futures Studies 81 (Aug. 2016), pp. 148–160. ISSN: 0016-3287. DOI: 10.1016/j.futures.2015.09.004. URL: https://www.sciencedirect.com/science/article/pii/S0016328715001342 (visited on 02/10/2025).

[154] Graham Leicester. *Transformative innovation in education: a playbook for pragmatic visionaries. Triarchy Press.*

[155] Allan McConnell and Paul 'T Hart. "Inaction and public policy: understanding why policymakers 'do nothing'". en. In: *Policy Sciences* 52.4 (Dec. 2019), pp. 645–661. ISSN: 0032-2687, 1573-0891. DOI: 10.1007/s11077-019-09362-2. URL: http://link.springer.com/10.1007/s11077-019-09362-2 (visited on 06/05/2025).

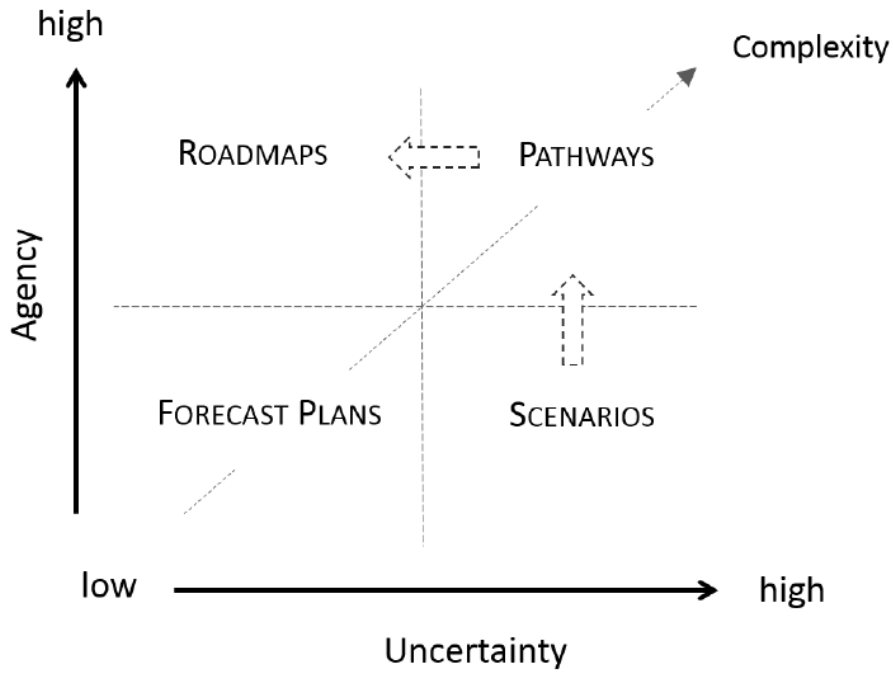

FIGURE 11: UNDERSTANDING THE ROLE OF PATHWAYS, SUCH AS THE THREE HORIZONS FRAMEWORK, IN COMPARISON TO OTHER STRATEGIC FORESIGHT METHODS. THIS IS BENCHMARKED AGAINST VARIABLES OF UNCERTAINTY AND AGENCY[156]

Reluctant Inaction: Inaction through reluctant acceptance that appropriate tools and resources are not available.

Inadvertent Inaction: Inaction as a product of bounded rationality constraints and institutional blind spots.

These types of inaction are often the product of myopic thinking required to achieve long-term resilience, based on psychological and organisational barriers to long-term systems thinking.[157]

6.3 SETH BAUM'S THEORY OF RESILIENCE AND CATASTROPHE TRAJECTORIES

Seth Baum's work on resilience and recovery from shocks and stresses explores how human civilisation navigates long-term trajectories.[159] He identifies four key trajectories: Status-Quo, Catastrophe, Technological Transformation, and Astronomical (Figure 13). A long-term trajec-

[156] Sharpe et al., "Three horizons".

[157] Alberto Feduzi, Jochen Runde, and Gary Schwarz. "Unknowns, Black Swans, and Bounded Rationality in Public Organizations". en. In: *Public Administration Review* 82.5 (Sept. 2022), pp. 958–963. ISSN: 0033-3352, 1540-6210. DOI: 10.1111/puar.13522. URL: https://onlinelibrary.wiley.com/doi/10.1111/puar.13522 (visited on 06/05/2025).

[158] Sharpe et al., "Three horizons".

[159] Baum et al., "Long-term trajectories of human civilization".

Looking from this Horizon	Looking at this Horizon	Negative (Mindset)	Positive (Perspective)
Horizon 1	Horizon 1	Competitor. Beat or take over.	Useful infrastructure. Potential allies in lobbying for shared interests, etc.
	Horizon 2	Parasite of potential investment. Watch and monitor.	Source of abundant ideas. Improvement. Changes scope of what can be done.
	Horizon 3	Fanciful and irrelevant. Ignore, or kill to prevent momentum building that would challenge H1 dominance.	Hope for the future. Possibility of renewal. Not challenging H1 role: relates to more of my life than H1.
Horizon 2	Horizon 1	Slow-moving dinosaurs. Obstructive. Get out of the way!	Holding the "innovator's dilemma." Destination for innovation. Arena of action. Source of support and ways to scale up.
	Horizon 2	Competitors for resources.	Allies in creating momentum.
	Horizon 3	Impractical.	Inspirational. Source of ideas and visibility. Sense of direction.
Horizon 3	Horizon 1	Massive error and liability, barrier to progress.	Potential resource when unlocked. Skills that can be redeployed—to scale. Valuable heritage and gains to be protected.
	Horizon 2	Obstructive compromise. They are misusing our vision.	Potential allies. Promising practice, stepping stone. Changes scope of what is possible.
	Horizon 3	Vision competitors: debate vigorously.	Extends the debate beyond the present; brings deeper issues of value into play.

FIGURE 12: INDICATES THE INTERACTION OF EACH HORIZON, AND HOW THIS INTERACTION RESULTS IN THE NECESSARY SHORT, MEDIUM AND LONG TERM CHANGES TOWARDS A MORE RESILIENT FUTURE[158]

tory refers to the path human civilisation takes into the distant future, which could span as long as civilisation itself endures.

- The **status-quo trajectory** refers to the future path in which human civilisation continues more or less as it is today, without major disruptions or transformations. This trajectory assumes that current societal, environmental, and technological trends, such as environmental degradation and technological advancement, continue relatively steadily, though it acknowledges uncertainties about how these factors might evolve over time. However, this also means there are significant risks of catastrophes developing if the status-quo continues, particularly if short-termist policymaking practices continue to dominate without due consideration of long-term foresight and risk management.
- The **catastrophe trajectory** involves a major, often irreversible event or series of events that significantly disrupt or even collapse advanced human civilisation. This could result from catastrophic risks, such as pandemics, nuclear war, climate change, or other global threats, leading to a loss of civilisation's current structure, technological capacity, and societal systems.
- The **technological transformation trajectory** describes a future where significant breakthroughs in technology lead to profound changes in human society, economy, and en-

[160] Baum et al., "Long-term trajectories of human civilization".

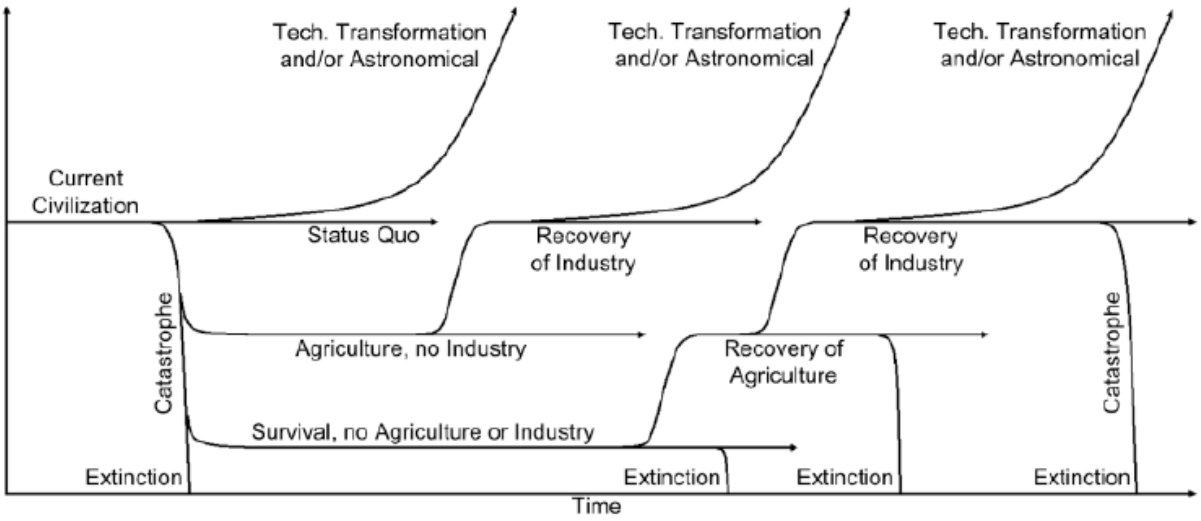

FIGURE 13: DEMONSTRATION OF ILLUSTRATIVE CATASTROPHE TRAJECTORIES [160]

vironment. These changes might include advancements like artificial intelligence, nanotechnology, or biotechnology, which have the potential to reshape civilisation's structure, increase human capabilities, and potentially solve some of the major challenges faced by humanity.

- The **astronomical trajectory** looks at the possibility of human civilisation expanding beyond Earth, such as through space colonisation. This trajectory envisions the long-term survival and growth of humanity in space, spreading across different planets and potentially encountering new forms of challenges or opportunities beyond our current planetary constraints.

Baum emphasises that decision-making should prioritise resilience by reducing existential risks - minimising the likelihood of human extinction or catastrophic events that could lead to the irreversible collapse of advanced civilisation. Policies should also accelerate technological progress in ways that enhance human welfare, promote space colonisation, and improve near-term well-being to strengthen overall resilience.

Status-quo trajectories describe a future where civilisation continues in its current form. However, uncertainty remains about how much deviation from present conditions would still be considered 'status-quo'. Examples include ongoing environmental degradation and technological advancement. Short-term assessments, such as UN population projections and IPCC reports, provide insights into near-term possibilities but may not capture long-term shifts.

Ultimately, Baum's framework highlights the importance of systems thinking in resilience, ensuring that humanity can recover from disruptions, adapt to emerging challenges, and sustain progress over the long term.

In his exploration of long-term trajectories of human civilisation, he/they utilises illustrative

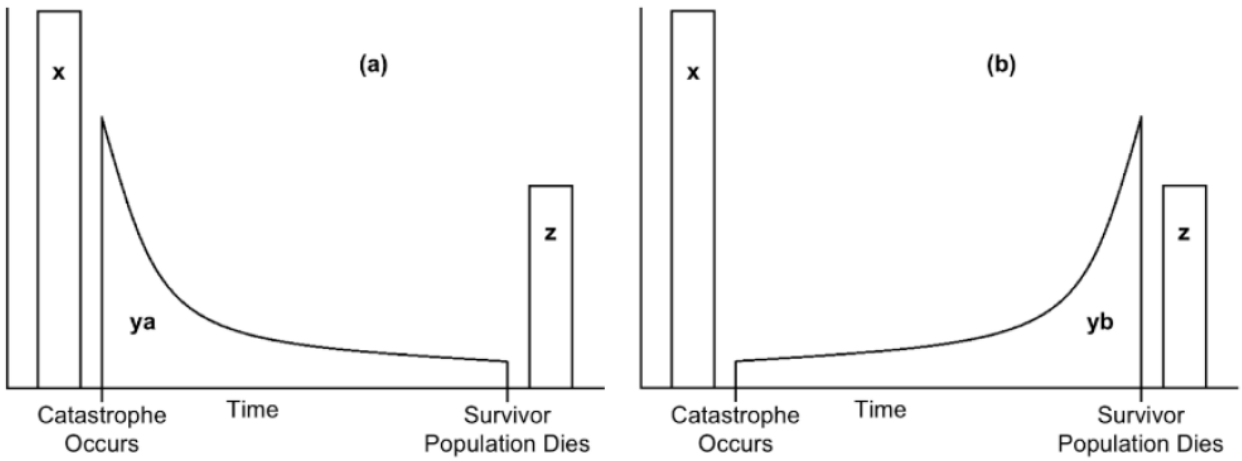

FIGURE 14: ILLUSTRATIVE PROBABILITY DISTRIBUTIONS OF A POST-CATASTROPHE AGRICULTURE [161]

probability distributions to model potential outcomes following global catastrophic events. These distributions aid understanding of likelihood and timing of recovery or collapse in various societal aspects, such as agriculture.

Baum presents two illustrative probability distributions regarding the redevelopment of agriculture post-catastrophe. Each distribution comprises three components:

1. **Probability of Agriculture Being Unaffected** (x): The chance that agriculture remains intact and continues without interruption.

2. **Probability of Agriculture Being Lost and Never Redeveloped** (z): The likelihood that agriculture is lost and not restored.

3. **Probability of Agriculture Being Lost and Subsequently Redeveloped** (ya and yb): The chances of agriculture being lost and later re-established, with ya and yb representing the probability per unit time of redevelopment after the catastrophe occurs.

These are outlined in Figure 14 and Figure 15.

These distributions illustrate varying scenarios of agricultural recovery, providing insights into the resilience of human societies in the face of catastrophic events. Baum emphasises that these models are for illustrative purposes and should not be taken as precise predictions.

By employing such probability distributions, Baum contributes to a deeper understanding of the dynamics at play in post-catastrophe recovery, highlighting the importance of considering both immediate and long-term factors in resilience planning.

[161] Baum et al., "Long-term trajectories of human civilization".

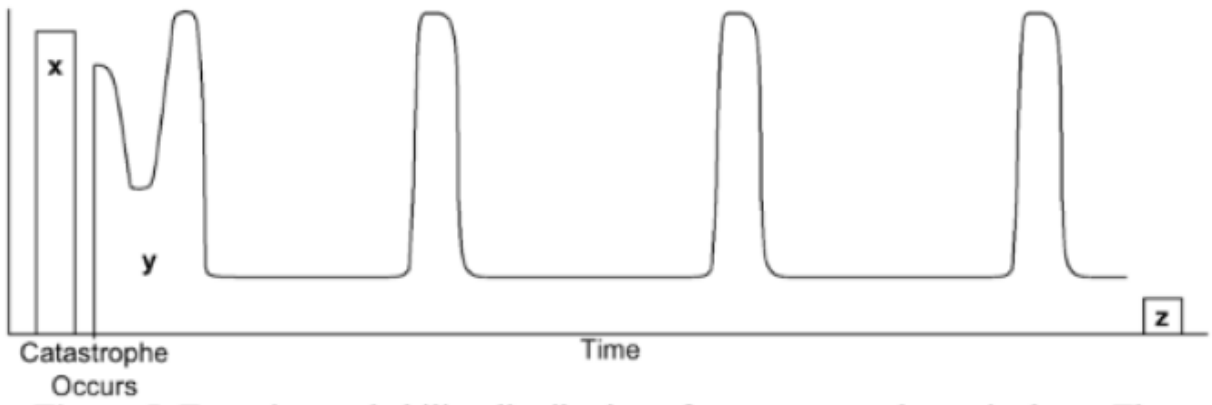

FIGURE 15: TENTATIVE PROBABILITY DISTRIBUTION OF POST-CATASTROPHE AGRICULTURE[162]

7 SCENARIOS - IDEATING MORE RESILIENT FUTURES

Scenariomapping can offer coherent, tangible ways of identifying different 'resilience futures', and the factors required to achieve a preferred, resilient future. It interrogates multiple futures, and does not assume that any particular future will necessarily be the one that manifests over time.

There are several ways to conduct scenario mapping, including step-by-step causal factors leading to recovery, as shown in Figure 16.

As explored in this report, resilience requires the co-design and co-production of policies that tie together 'top-down' and 'bottom-up' policy capacity (organisational and systemic policy capacity, respectively). Scenarios naturally help us identify preferred resilient futures that encapsulate the blend of these policy capacities.

Using causal layered analysis (CLA) incasting, it is possible to develop scenarios related to organisational and systemic policy capacity and its implications for resilience, based on the factors of CLA.[163] CLA incasting is a combination of CLA and double variable scenario mapping.

CLA requires phenomena to be analysed through the following characteristics

Litany: is the most visible and obvious phenomena. These are surface level events and facts.

Systemic: The underlying systemic drivers underpinning the litany layer. Exploring this layer deepens the understanding of connections between systemic causes and the surface level characteristics of the litany.

[162] Baum et al., "Long-term trajectories of human civilization".

[163] Sohail Inayatullah. "Causal layered analysis". en. In: *Futures* 30.8 (Oct. 1998), pp. 815–829. ISSN: 00163287. DOI: 10.1016/S0016-3287(98)00086-X. URL: https://linkinghub.elsevier.com/retrieve/pii/S001632879800086X (visited on 06/05/2025).

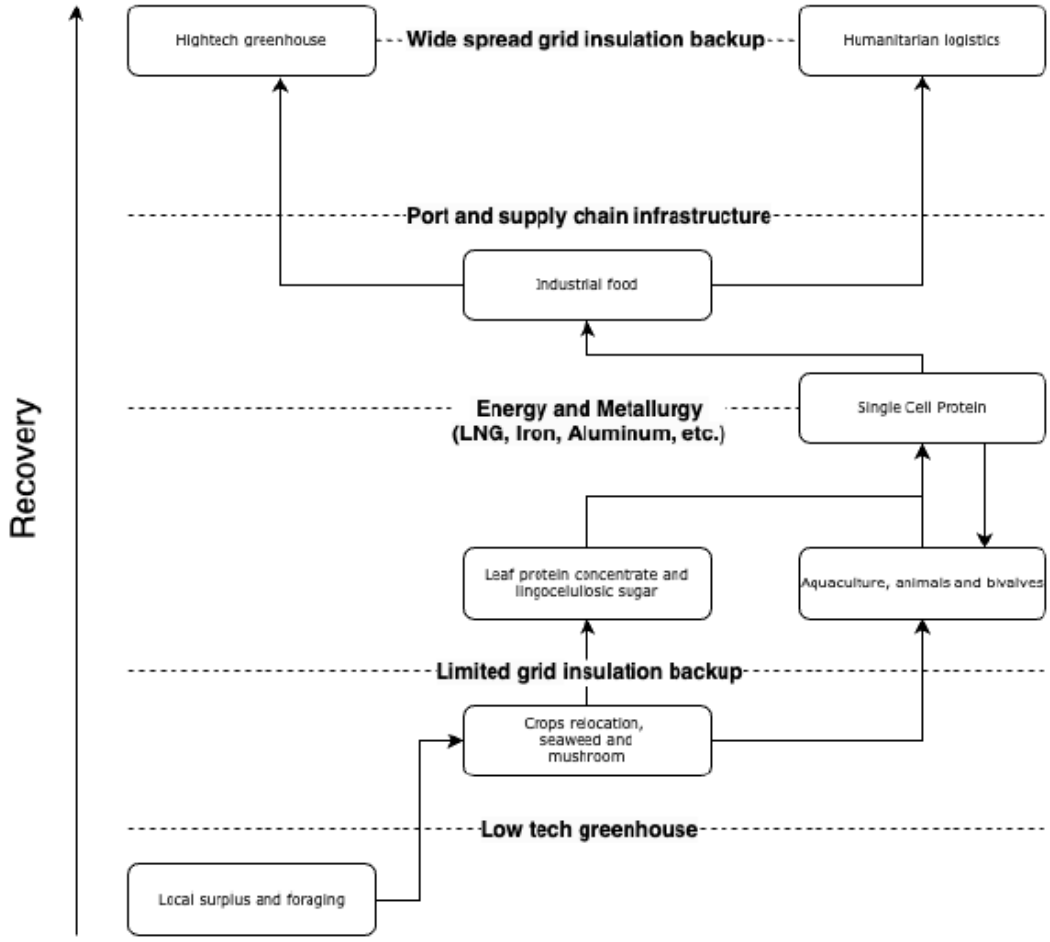

FIGURE 16: CAUSAL STEPS TO RECOVERY FROM A SHOCK AND/OR STRESS: THE CASE OF ENERGY SECURITY

FIGURE 17: CLA INCASTING FRAMEWORK, USING VARIABLES OF ORGANISATIONAL AND SYSTEMIC POLICY CAPACITY.

Worldviews: the collective norms, standards and morals that individuals believe they should maintain, most often influenced by religious viewpoints, political allegiances, or professional practices.

Metaphor: The underlying myths and metaphors representing an unconscious dimension of the issue. This layer requires inner transformation, enabling the development of new narratives and perspectives

An applied example of CLA can be seen in Appedix Item G, pertaining to extreme heat governance scenarios for Greater Sydney, based on the work of James Balzer.[164]

Similarly, CLA can be used to chart avenues to stronger long-term resilience, in a more processual way, through the use of the Change Progression Scenario (CPS) Method.[165] This method involves assessing the following scenarios through using CLA:

- **No change:** A business-as-usual scenario where there is no key systemic change in underlying characteristics

[164] James Balzer. "Extreme Heat Governance Futures for Sydney - What Now, and What If?" In: (2025). URL: https://jfsdigital.org/extreme-heat-governance-futures-for-sydney-what-now-and-what-if-3/.

[165] Ivana Milojevic. *Educational Futures*. en. 0th ed. Routledge, May 2005. ISBN: 978-1-134-31644-1. DOI: 10.4324/9780203413982. URL: https://www.taylorfrancis.com/books/9781134316441 (visited on 06/05/2025).

- **Marginal change:** A change where small shifts and iterations occur to the status quo, but nothing transformative or disruptive
- **Adaptive change:** The beginning of disruptive and transformative change that can drive long-term shifts in patterns and characteristics of the scenario
- **Radical change:** A disruptive, transformative change from the business-as-usual scenario, leading to longer term, systemic change

A table of this information is seen in Table 5.

Sohail Inyatullah also argues the need to use the Futures Triangle[166] to understand what can draw society towards a better future (the pull from the future), what compels society to move towards a better future (the pushes of the present) but also what is preventing long-term change (the weight of history) (see Figure 18).

It is possible to overlay the CPS method on the Futures Triangle to understand the drivers of and barriers to achieving long-term change.[167]

Seth Baum's research on resilience emphasises the importance of understanding and preparing for various levels of severity in potential disruptions to human civilisation. He advocates for enhancing resilience to a broad spectrum of threats, regardless of their specific nature, probability, or severity. This approach involves developing systems capable of withstanding diverse challenges, thereby ensuring the continuity of essential functions even under adverse conditions.

In his 2015 paper, "Risk and Resilience For Unknown, Unquantifiable, Systemic, and Unlikely Catastrophic Threats,"[168] Baum discusses the suitability of resilience as a framework for addressing threats that are unknown or unquantifiable. He suggests that, in the absence of specific information about such threats, enhancing resilience is a prudent strategy.

While Baum focuses on the broad enhancement of resilience, Lewis Dartnell's "The Knowledge: How to Rebuild Our World from Scratch" delves into the practical aspects of restoring productive capacities following catastrophic events.[169] Dartnell provides a roadmap for rebuilding critical infrastructure and technologies, emphasising the importance of understanding scientific and technological principles to facilitate recovery.

[166] Sohail Inayatullah. "Six pillars: futures thinking for transforming". en. In: *Foresight* 10.1 (Feb. 2008), pp. 4–21. ISSN: 1463-6689. DOI: 10.1108/14636680810855991. URL: https://www.emerald.com/insight/content/doi/10.1108/14636680810855991/full/html (visited on 06/05/2025).

[167] Ivana Milojević. "Contextualising Conflict: The Futures Triangle". en. In: *World Futures Review* 15.2-4 (Dec. 2023), pp. 122–132. ISSN: 1946-7567, 2169-2793. DOI: 10.1177/19467567231203160. URL: https://journals.sagepub.com/doi/10.1177/19467567231203160 (visited on 06/05/2025).

[168] Seth D. Baum. "Risk and resilience for unknown, unquantifiable, systemic, and unlikely/catastrophic threats". en. In: *Environment Systems and Decisions* 35.2 (June 2015), pp. 229–236. ISSN: 2194-5403, 2194-5411. DOI: 10.1007/s10669-015-9551-8. URL: http://link.springer.com/10.1007/s10669-015-9551-8 (visited on 06/05/2025).

[169] Lewis Dartnell. *The knowledge: how to rebuild our world from scratch*. eng. OCLC: 868380289. London: The Bodley Head, 2014. ISBN: 978-1-84792-227-4.

	No Change	Marginal Change	Adaptive Change	Radical Change
Scenario Title	Business-as-usual	Signal	Trend	Paradigm Shift or Step Change
Systemic Change (Underlying causes of this scenario)	What is causing this current, business-as-usual scenario, that is driven by path dependence and inertia?	What might lead to a marginal change in the current state of this particular policy issue?	What are the major shifts that might cause the significant change that result in this scenario?	What step-change causes are necessary to significantly change the scenario of this policy issue?
Worldview (Underlying assumptions that lead to the underlying causes)	What worldviews and perceptions legitimise the casualties of this particular scenario?	What shifts in people's worldviews and perceptions and required to lead to a marginal change of this particular policy issue?	What new worldviews and perceptions are necessary to lead to this more significant shift?	What worldviews and perceptions are required to legitimise a need for step-change of this nature, to get to this scenario?
Core Myth/Metaphor (summary of this scenario)	How do we describe this scenario using a succinct metaphor?	How do we describe this scenario using a succint metaphor?	How do we describe this scenario using a succinct metaphor?	How do we describe this scenario using a succint metaphor?
Consequence (The real-world impact of this scenario)	What are the consequences of not changing?	What are the consequences (positive and negative of marginal change?	What are the consequences (positive and negative) of adaptive change?	What are the consequences (positive) of radical change?

TABLE 5: TABULATED FRAMEWORK FOR CPS METHOD

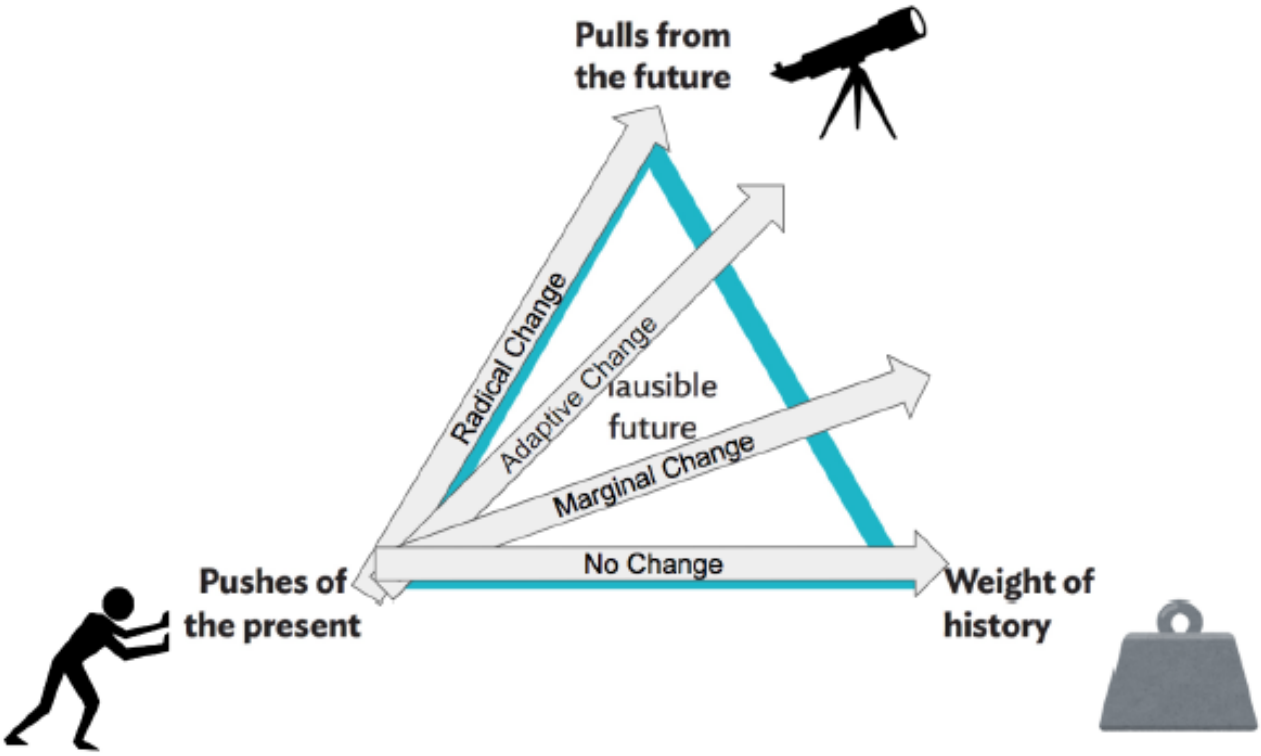

FIGURE 18: OVERLAYING THE CPS METHOD AND THE FUTURES TRIANGLE.

Dartnell's work is not merely a guide to survival skills but a comprehensive manual on reconstructing the complex systems that underpin modern society. He addresses the restoration of various productive capacities, including agriculture, manufacturing, and energy production, offering insights into how these sectors can be reestablished after a collapse. For example, he explores methods for purifying water, producing soap, generating power, and cultivating food, all of which are essential for the revival of productive capacities.

8 MISSION-ORIENTED POLICIES, AND BUILDING A RESILIENT FUTURE

This report previously explored Mariana Mazzucato's mission-oriented policy making framework[170] as a way of enabling higher wellbeing and economic opportunities in society. Mariana Mazzucato mission-driven policy-making framework centres on setting ambitious, clear objectives to address societal challenges, thereby fostering innovation and guiding public and private investments toward common goals.[171] This approach positions governments not merely

[170] Mazzucato and Dibb, *Missions: A beginner's guide*.

[171] Mariana Mazzucato, Rainer Kattel, and Josh Ryan-Collins. "Challenge-Driven Innovation Policy: Towards a New Policy Toolkit". en. In: *Journal of Industry, Competition and Trade* 20.2 (June 2020), pp. 421–437. ISSN: 1566-

as regulators but as active participants in shaping markets and driving systemic change.

Key elements of the mission-oriented policy making include:

1. **Mission-Oriented Goals:** Define specific, measurable objectives that tackle complex issues such as climate change or public health crises. These missions serve as focal points for coordinated efforts across various sectors.

2. **Market-Shaping Role of Government:** Recognise that governments can actively shape markets rather than just correcting market failures. This involves strategic investments and policy interventions that align public and private sector efforts toward mission objectives. In this sense, governments don't just 'steer' an economy, but also 'row' it.

3. **Inclusive Innovation Systems:** Promote innovation ecosystems that include diverse stakeholders, ensuring that technological advancements contribute to societal well-being.

This has significant implications for creating stronger resilience and sustainability.

Enhanced Resilience. By addressing systemic challenges through coordinated missions, societies can develop robust systems capable of adapting to and recovering from disruptions, thereby enhancing overall resilience.

Sustainable Development. Aligning missions with sustainability goals ensures that economic growth does not come at the expense of environmental health, fostering long-term ecological balance and societal wellbeing.

The framework to achieve this is outlined in Figure 19.

Grand Challenge. These are broad, significant societal issues that require collective action, such as climate change, aging populations, or digital transformation.

Mission. Derived from grand challenges, missions are specific, measurable objectives designed to address these broader issues. They provide clear direction and targets, such as achieving carbon-neutral cities by a set year.

Sector. These are distinct areas of the economy, like energy, healthcare, or transportation, that contribute to achieving the mission.

Mission Projects. Concrete initiatives within sectors that directly work towards fulfilling the mission's objectives. These projects involve collaboration across various stakeholders, including public agencies, private companies, and research institutions.

1679, 1573-7012. DOI: 10.1007/s10842-019-00329-w. URL: http://link.springer.com/10.1007/s10842-019-00329-w (visited on 06/05/2025).

[172] Mazzucato and Dibb, *Missions: A beginner's guide*.

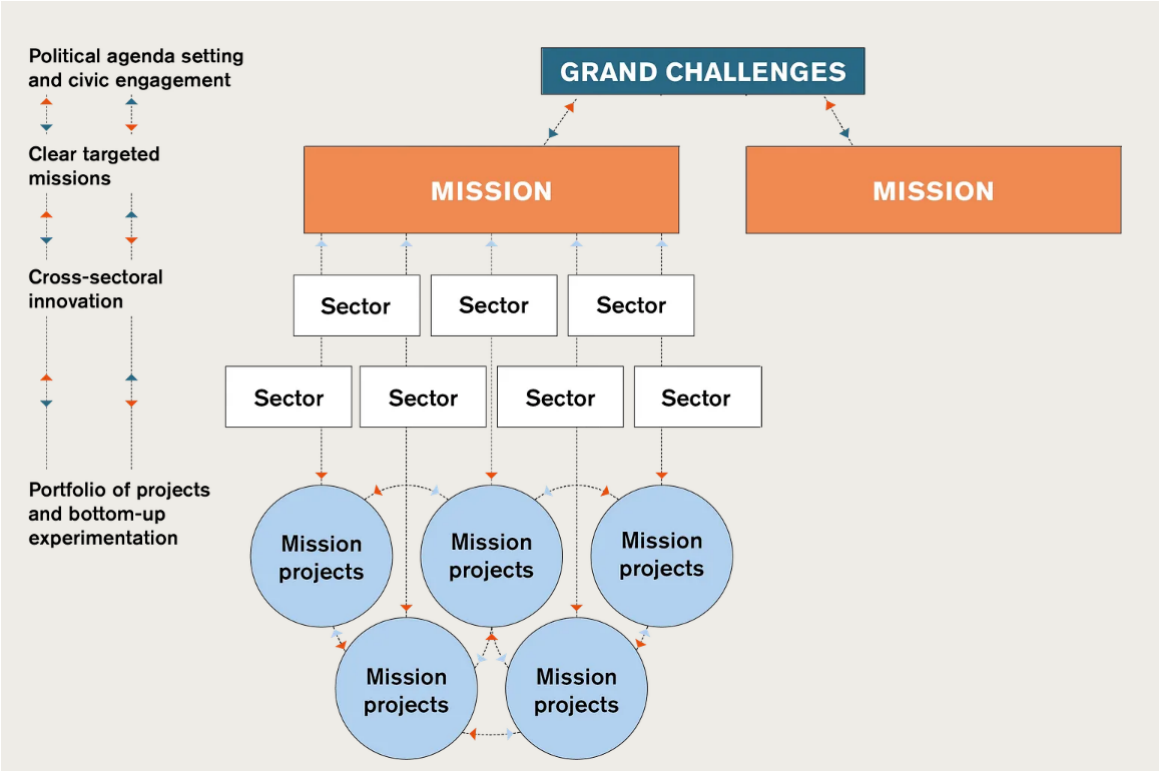

FIGURE 19: MISSION-ORIENTED POLICY FRAMEWORK PROPOSED BY MARIANA MAZZUCATO[172]

Traditional policymaking often focuses on specific sectors or technologies, addressing issues in isolation without a unified direction. In contrast, mission-oriented policymaking adopts a holistic, problem-solving approach, setting clear goals that require coordinated efforts across multiple sectors and disciplines. This strategy transforms the role of government from a passive regulator to an active market shaper, fostering innovation and guiding investments towards societal challenges.

By targeting systemic challenges, mission-oriented policies inherently promote resilience. They encourage the development of adaptable systems capable of withstanding and recovering from disruptions. For example, a mission aimed at sustainable urban development would not only address environmental concerns but also enhance infrastructure robustness, social equity, and economic stability, collectively contributing to a more resilient society. Mariana Mazzucato's mission-oriented policy framework offers a strategic approach to developing Shared Socio-economic Pathways (SSPs)[173] that harmonises economic growth with climate neutrality. By focusing on clear, ambitious missions, this framework aligns diverse sectors and stakeholders toward common goals, facilitating systemic innovation and sustainable development.

[173]Keywan Riahi et al. "The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview". en. In: *Global Environmental Change* 42 (Jan. 2017), pp. 153–168. ISSN: 09593780. DOI: 10.1016/j.gloenvcha.2016.05.009. URL: https://linkinghub.elsevier.com/retrieve/pii/S0959378016300681 (visited on 06/05/2025).

GRAND CHALLENGES AND MISSIONS

Identifying grand challenges, such as climate change, sets the stage for defining specific missions aimed at achieving climate neutrality. For instance, the European Union's Cities Mission seeks to establish 100 climate-neutral and smart cities by 2030, addressing the climate crisis through comprehensive systemic change.

SECTORAL INTEGRATION

Missions necessitate collaboration across various sectors, including energy, transportation, and manufacturing. This integrated approach ensures that sector-specific policies contribute collectively to overarching objectives like climate neutrality, promoting cohesive and efficient progress.

MISSION PROJECTS

Implementing targeted mission projects fosters innovation and investment, driving economic growth while addressing environmental goals. For example, public investments in renewable energy technologies can stimulate private sector engagement, leading to sustainable economic expansion.

POLICY IMPLICATIONS

Embracing mission-oriented policymaking requires governments to adopt a market-shaping role, steering economic activities toward societal challenges. This proactive stance enables the creation of new markets and industries aligned with climate objectives, facilitating the development of SSPs that balance economic growth with environmental sustainability. By defining grand challenges, setting clear missions, integrating sectoral efforts, and implementing targeted projects, mission-oriented policymaking supports the creation of SSPs that promote both economic growth and environmental sustainability.

Combining the threads of GRAIN might proceed as follows:

- By first convening relevant global and local experts for foresight activities, we can distil a range of insights relevant to resilience frameworks. These could engage both short and long term incentives for building resilience, across sectoral and temporal trajectories of policy. These would then identify key risks and opportunities for the relevant polity or organisations involved.

- Next, scenario-based exploration of trade-offs, exposures, and advantages involved in the key systems identified could be developed. Doing so enables existing policymakers, or the general public, to create a participatory set of interventions that raise competitiveness in industrial policy while also contributing to global adaptive capacity.

As explored, foresight methodologies to achieve this might include:

- **Causal Layered Analysis (CLA):** a way of understanding deeper systemic causes of complex phenomena,
- **The Futures Triangle:** a way to understand the drivers of (in)action
- **Scenario Mapping:** to ideate different futures of particular policy domains, especially in domains of complexity and uncertainty

The policies gleaned through these methods could then spread further through the communities of practice, diplomatic cooperation, and best practice published in academia. By iterating the Odyssean Process in numerous locations, GRAIN could be refined for local and global contexts. The set of interventions developed could be structured as mission-oriented public policy, setting out a strong set of ambitious goals into processes and outcomes which can produce impactful, measurable improvements in wellbeing and resilience at different scales of governance.

For example, GRAIN can analyse countries like Iceland as a 'node of persisting complexity', that enables resilience in trade stocks and flows, particularly in products like seaweed, maize and field bean. Additionally, GRAIN can analyse Iceland's role as a node of energy resilience, due to its strong indigenous renewable energy sources. Iceland's institutional robustness in strong public services, transparent governance, deliberative democracy, and higher tech economic aspects mark it out as a vital testbed for innovations in applying more concrete, object-level investment strategies. In this sense, it is a strong case study in resilience.

9 CONCLUSION

Resilience is a deeply polysemic and contested concept, requiring a transdisciplinary, systems-thinking approach that spans multiple policy domains. The various interpretations of resilience—from ecological and technological to social and institutional—demonstrate its complexity and the necessity of integrating diverse perspectives. Scholars such as Seth Baum, Igor Linkov, and Lewis Dartnell offer overlapping yet distinct views on resilience, emphasizing everything from catastrophe trajectories to cognitive resilience and the restoration of productive capacities. A comprehensive understanding of resilience, therefore, demands an appreciation of these varied contributions.

We also want to assess the risks of trade exposure, in the event of major shocks or stresses, but also how Revealed Comparative Advantage (RCA) can enable global 'nodes' to be pillars of resilience and recovery during global shocks and stresses. Building resilience requires strong policy capacity, particularly a blend of organizational and systemic policy capacity. Governments alone cannot achieve resilience; rather, bridging across government, civil society, and

business stakeholders is essential to ensure effective responses to shocks and stresses. This aligns with the mission-oriented governance framework, which structures efforts to address grand challenges by integrating multiple sectors and actors under shared goals—coordinated by the government using all the tools at its disposal. By adopting mission-oriented policies, societies can navigate complexity while maintaining coherence in resilience-building efforts.

Moreover, resilience is both a materialist and non-materialist concept. Materialist aspects focus on tangible elements such as infrastructure, food supply chains, and resource security, while non-materialist aspects emphasise institutional resilience, governance frameworks, and adaptive capacities. For example, a mission for food sovereignty and security ensures supply-chain resilience by shifting from purely just-in-time models to more robust just-in-case systems. Strengthening and multiplying supply chains in this way enhances food security and reduces vulnerabilities to external shocks.

Ultimately, resilience is not a static state but a dynamic, evolving capacity that must be continuously reinforced through coordinated, forward-thinking policymaking. By integrating diverse perspectives, fostering cross-sector collaboration, and adopting mission-driven strategies, societies can enhance their ability to withstand and adapt to future challenges. Through this, they can collaborate to overcome what has very recently seen more unilateral, nationalistic trade policies abruptly reneging on prior globalisation, which itself did not necessarily proceed with long term planning around resilience in mind either. Industrial policy and institutional enhancement can then work side by side, to pursue more comprehensive wellbeing that is robust to unavoidable uncertainties.

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A APPENDIX ITEM: SUMMARY OF FOOD MATERIALIST RESILIENCE

Type	Why?	Example	Linkov Matrix Factors
Seaweed (Gracilaria tikvahiae)	Fast growing and highly scalable aquaculture product that does not compete with resource intensive land crops (fertiliser, freshwater, and pesticides). Seaweed thrives in the first few years after ASRS as nutrients are brought to the surface as seawater temperature drops, making it an ideal candidate for early recovery. 45% of human food demand on an average of 10 years.	(Jehn et al. 2024)	Absorb; Recover; Adapt
Mushroom	Although not calorie dense, mushroom thrives in ideal ASRS environments. For supplementing micronutrients and Vitamin-D if treated with UV. Currently price is high but can be grown domestically with little training and knowledge	(García Martínez et al. 2025; Denkenberger et al. 2018; Denkenberger & Pearce 2014)	Absorb; Recover; Adapt
Cold-resistant staples relocation	Primarily focus on relocating crops such as potato, rapeseed, wheat, sugar beet, barley, and beans towards lower latitudes. Use of low-tech greenhouse could expand areas of cultivation.	(Rivers et al. 2024; Davis et al.,2017; Wilson et al.2023)	Absorb; Recover
Single-Cell Protein & Synthetic Fat	Protein produced using methanotrophic bacteria extracted from natural gas and synthetic fat from paraffin. Approximating to 19-31% of caloric requirement post ASRS. SCP can achieve high caloric and high protein completeness given limited land use and resources input. Providing good supplementation for micro-nutrients found in animal products. Will require LNG and biogas infrastructures. But ramp-up is slow and is capital intensive.	TEMASEK have already been investing in commercially-viable SCP solutions, currently focused on producing animals, pets, and aquaculture feeds (García Martínez et al. 2022; García Martínez et al. 2022; García Martínez et al.2025) Pilot production of SCP in Lavera and Grangemouth refinery were explored by BP back in 1960s. Marketed as Toprina, it was sold as animal feed (Jenkins G. 1988).	Adapt

TABLE 6: APPENDIX ITEM A

B APPENDIX ITEM: SUMMARY OF NON-FOOD MATERIALIST RESILIENCE

Type	Why?	Example	Linkov Matrix Factors
Liquified Natural Gas (LNG) and associated infrastructures	LNG continues to be a major source of energy source. From direct use to as part of electricity mix. LNG is one of the cleaner forms of fossil fuel. Food wise, LNG is not only a precursor to the production of nitrogen based fertiliser, but could also derive as methane based Single-Cell Protein for resilience food.LNG require energy intensive cryogenic storage	Nigeria LNG on Bonny Island, one of the largest production facilities.	**Absorb, Recover, Adapt**
Semiconductors	These are essential components of advanced, technical economy and societal communications and computing systems, with major knock on effects for modelling and simulating wicked problems and their solutions.	Estimated 90% (Chip Wars) are produced in Taiwan, a geopolitically fraught island caught between USA-China Cold War tensions, and in proximity to volcanic eruptions (see: Lara Mani's work).	
Steel, Aluminum, and Copper	Metals fundamental to modern infrastructure from LNG, electricity grid, to freight and port facilities.Collapse of metal industry and trade could spell delays towards trading infrastructure repairment and connections Global Catastrophe.	Steel is an indispensable for the machineries required for maintenance of modern day infrastructure, from transport, logistics to energy systems (Smil V., 2016). Copper in conjunction with steel forms the backbone of communication infrastructure from submarine to premise. Aluminum and Steel are for powerlines.	
Electricity Grid backup	Stockpiles of transformers could facilitate ramp-up of grid after Nuclear EMP like GCR.	Simulations based on North America suggest that extended outages of the grid from HEMP could reduce human caloric consumption from 38 to 65% through the disruption of the food supply chain at every level (Blouin et al., 2015).	**Absorb; Recover**
Port infrastructure at maritime chokepoints	The risk of shutting down global trading chokepoint can have cascading consequence for the delivery of food and fuel.Key trading chokepoints have always been contentious for regional and global powers.Maintaining trade flow in an event of GCR and GCIL could prevent the worst case scenario, allowing for relocation of cold-resistant crops and delivery of essential medicine and resilient food.	In ASRS scenario from the worst case of nuclear exchange (150 Tg), maintenance of trade without resilience food adaptation could meet 19% of nutritional requirement globally (Rivers et al., 2024)Several studies using Complex Adaptive System modelling looked at potential shutdown of the strait of Malacca, Hormuz, and Red Sea will require re-routing of global trade routes for oil and gas export (Meza et al., 2022; Komiss & Hutzinger, 2011) (Jehn et al., 2024b)	**Plan; Absorb Recover**
High-tech greenhouse	High tech solution applicable for preactive and proactive resilience which will enable high productive climate-control. Not applicable under certain scenario where there is a black-out and energy collapse. In DMDU, not extreme pathways.		

TABLE 7: APPENDIX ITEM B

C APPENDIX ITEM: MEAN RCA VALUES AND RELEVANT INDEX VALUES THAT CALCULATE SUPPLY CHAIN RESILIENCE AND MATURITY (STANDARD WEIGHTINGS)

- Mean RCA = 60% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 10% weighting
- LPI = 10% weighting

Country	Mean RCA	z-score	GDP	z-score	Energy Production	z-score	HDI	z-score	LPI	z-score	Index Value
Italy	8.84	5.20	2,300,940,000,000	0.76	0.76	-0.17	3.70	1.16	0.906	1.19	3.41
China	2.26	0.00	17,794,800,000,000	7.31	126.57	9.71	3.70	1.14	0.788	1.06	2.46
Mozambique	8.71	5.11	90,254,220,984	-0.21	0.65	-0.18	0.65	-5.17	0.461	-1.66	2.35
Eswatini	7.61	4.37	4,442,875,788	-0.22	0.65	-0.23	0.65	-5.17	0.461	-4.61	1.60
Argentina	4.93	2.56	646,075,000,000	0.06	3.44	0.04	2.80	-0.38	0.849	0.83	1.59
Romania	4.65	2.37	350,776,000,000	-0.07	0.80	-0.17	3.20	0.31	0.827	0.69	1.50
Trinidad and Tobago	4.84	2.50	27,372,285,698	-0.21	1.10	-0.15	2.50	-0.89	0.814	0.60	1.43
Cyprus	4.09	2.00	33,886,930,712	-0.20	0.00	-0.23	3.20	0.31	0.907	1.20	1.30
Finland	3.57	1.64	295,532,000,000	-0.09	0.53	-0.19	4.20	2.02	0.942	1.42	1.30
Papua New Guinea	4.78	2.46	30,729,242,919	-0.20	0.50	-0.19	2.70	-0.55	0.568	-0.97	1.28
Fiji	4.28	2.12	5,442,046,565	-0.22	0.00	-0.23	2.30	-1.23	0.729	0.06	1.11
Peru	3.88	1.82	267,603,000,000	-0.10	0.99	-0.16	3.00	0.19	0.762	0.27	1.11
Jamaica	4.21	2.08	19,423,355,409	-0.21	0.00	-0.23	2.50	-0.89	0.706	-0.09	1.10
Indonesia	3.40	1.52	1,371,170,000,000	-0.36	18.80	1.24	3.60	0.93	0.713	-0.04	1.07
New Caledonia	6.23	3.43	9,620,000,000	-0.21	0.00	-0.23	0.65	-5.17	0.461	-4.61	1.04
Hungary	3.21	1.40	212,389,000,000	-0.13	0.32	-0.21	3.20	0.31	0.851	0.84	0.92
Belarus	3.22	1.41	71,857,382,746	-0.19	0.19	-0.22	2.70	-0.55	0.804	0.61	0.91
Albania	3.36	1.50	23,647,179,830	-0.21	0.07	-0.23	2.70	-0.55	0.789	0.44	0.81
Switzerland	2.22	0.73	884,940,000,000	0.16	0.41	-0.20	4.10	1.85	0.967	1.58	0.76
Samoa	4.26	2.11	2,038,189,444	-0.22	0.00	-0.23	0.65	-5.17	0.702	-0.11	0.69
Estonia	3.28	1.43	41,291,245,222	-0.10	0.82	-0.23	3.60	0.99	0.899	1.15	0.69
Singapore	1.78	0.41	501,428,000,000	-0.01	0.02	-0.23	4.30	2.19	0.949	1.47	0.65
Lithuania	2.26	0.76	79,789,877,416	-0.18	0.02	-0.23	3.40	0.65	0.879	1.02	0.58

TABLE 8: APPENDIX ITEM C

D APPENDIX ITEM: MEAN RCA VALUES AND RELEVANT INDEX VALUES THAT CALCULATE SUPPLY CHAIN RESILIENCE AND MATURITY (WEIGHTINGS ADJUSTED)

- Mean RCA = 30% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 20% weighting
- LPI = 30% weighting

Country	Mean RCA	z-score	GDP	z-score	Energy Production	z-score	HDI	z-score	LPI	z-score	Index Value
China	2.26	0.00	17,794,800,000,000	7.31	126.57	9.71	3.70	1.14	0.788	1.06	2.25
Italy	8.84	5.20	2,300,940,000,000	0.76	0.76	-0.17	3.70	1.16	0.906	1.19	2.21
Finland	3.57	1.64	295,532,000,000	-0.09	0.53	-0.19	4.20	2.02	0.942	1.42	1.29
Switzerland	2.22	0.73	884,940,000,000	0.16	0.41	-0.20	4.10	1.85	0.967	1.58	1.06
Cyprus	4.09	2.00	33,886,930,712	-0.20	0.00	-0.23	3.20	0.31	0.907	1.20	0.98
Singapore	1.78	0.41	501,428,000,000	-0.01	0.02	-0.23	4.30	2.19	0.949	1.47	0.98
Romania	4.65	2.37	350,776,000,000	-0.07	0.80	-0.17	3.20	0.31	0.827	0.69	0.96
Argentina	4.93	2.56	646,075,000,000	0.06	3.44	0.04	2.80	-0.38	0.849	0.83	0.95
Estonia	3.28	1.43	41,291,245,222	-0.10	0.82	-0.23	3.60	0.99	0.899	1.15	0.94
Trinidad and Tobago	4.84	2.50	27,372,285,698	-0.21	1.10	-0.15	2.50	-0.89	0.814	0.60	0.72
Indonesia	3.40	1.52	1,371,170,000,000	-0.36	18.80	1.24	3.60	0.93	0.713	-0.04	0.72
Hungary	3.21	1.40	212,389,000,000	-0.13	0.32	-0.21	3.20	0.31	0.851	0.84	0.7
Peru	3.88	1.82	267,603,000,000	-0.10	0.99	-0.16	3.00	0.19	0.762	0.27	0.64
Lithuania	2.26	0.76	79,789,877,416	-0.18	0.02	-0.23	3.40	0.65	0.879	1.02	0.62
Belarus	3.22	1.41	71,857,382,746	-0.19	0.19	-0.22	2.70	-0.55	0.804	0.61	0.45
Albania	3.36	1.50	23,647,179,830	-0.21	0.07	-0.23	2.70	-0.55	0.789	0.44	0.43
Jamaica	4.21	2.08	19,423,355,409	-0.21	0.00	-0.23	2.50	-0.89	0.706	-0.09	0.37
Fiji	4.28	2.12	5,442,046,565	-0.22	0.00	-0.23	2.30	-1.23	0.729	0.06	0.36
Papua New Guinea	4.78	2.46	30,729,242,919	-0.20	0.50	-0.19	2.70	-0.55	0.568	-0.97	0.3
Mozambique	8.71	5.11	90,254,220,984	-0.21	0.65	-0.18	0.65	-5.17	0.461	-1.66	-0.04
Samoa	4.26	2.11	2,038,189,444	-0.22	0.00	-0.23	0.65	-5.17	0.702	-0.11	-0.48
Eswatini	7.61	4.37	4,442,875,788	-0.22	0.65	-0.23	0.65	-5.17	0.461	-4.61	-1.15
New Caledonia	6.23	3.43	9,620,000,000	-0.21	0.00	-0.23	0.65	-5.17	0.461	-4.61	-1.43

TABLE 9: APPENDIX ITEM D

E APPENDIX ITEM: MEAN RCA VALUES AND RELEVANT INDEX VALUES THAT CALCULATE SUPPLY CHAIN RESILIENCE AND MATURITY (WEIGHTINGS ADJUSTED, INCLUDING LATITUDE)

- Mean RCA = 50% weighting
- GDP = 10% weighting
- Energy Production = 10% weighting
- HDI = 10% weighting
- LPI = 10% weighting

Country	Mean RCA	z-score	GDP	z-score	Energy Production	z-score	HDI	z-score	LPI	z-score	Latitude	Index Value
China	2.26	0.00	17,794,800,000,000	7.31	126.57	9.71	3.70	1.14	0.788	1.06	35.9	2.31
Italy	8.84	5.20	2,300,940,000,000	0.76	0.76	-0.17	3.70	1.16	0.906	1.19	42.8	1.77
Finland	3.57	1.64	295,532,000,000	-0.09	0.53	-0.19	4.20	2.02	0.942	1.42	64.0	1.28
Switzerland	2.22	0.73	884,940,000,000	0.16	0.41	-0.20	4.10	1.85	0.967	1.58	46.8	1.08
Estonia	3.28	1.43	41,291,245,222	-0.10	0.82	-0.23	3.60	0.99	0.899	1.15	58.6	0.93
Singapore	1.78	0.41	501,428,000,000	-0.01	0.02	-0.23	4.30	2.19	0.949	1.47	1.3	0.89
Cyprus	4.09	2.00	33,886,930,712	-0.20	0.00	-0.23	3.20	0.31	0.907	1.20	35.1	0.83
Romania	4.65	2.37	350,776,000,000	-0.07	0.80	-0.17	3.20	0.31	0.827	0.69	45.9	0.81
Lithuania	2.26	0.76	79,789,877,416	-0.18	0.02	-0.23	3.40	0.65	0.879	1.02	55.2	0.67
Hungary	3.21	1.40	212,389,000,000	-0.13	0.32	-0.21	3.20	0.31	0.851	0.84	47.2	0.65
Argentina	4.93	2.56	646,075,000,000	0.06	3.44	0.04	2.80	-0.38	0.849	0.83	-38.4	0.52
Indonesia	3.40	1.52	1,371,170,000,000	-0.36	18.80	1.24	3.60	0.93	0.713	-0.04	-0.8	0.51
Trinidad and Tobago	4.84	2.50	27,372,285,698	-0.21	1.10	-0.15	2.50	-0.89	0.814	0.60	10.7	0.44
Belarus	3.22	1.41	71,857,382,746	-0.19	0.19	-0.22	2.70	-0.55	0.804	0.61	53.7	0.43
Peru	3.88	1.82	267,603,000,000	-0.10	0.99	-0.16	3.00	0.19	0.762	0.27	-9.2	0.37
Albania	3.36	1.50	23,647,179,830	-0.21	0.07	-0.23	2.70	-0.55	0.789	0.44	41.2	0.35
Jamaica	4.21	2.08	19,423,355,409	-0.21	0.00	-0.23	2.50	-0.89	0.706	-0.09	18.1	0.17
Fiji	4.28	2.12	5,442,046,565	-0.22	0.00	-0.23	2.30	-1.23	0.729	0.06	-17.7	0.04
Papua New Guinea	4.78	2.46	30,729,242,919	-0.20	0.50	-0.19	2.70	-0.55	0.568	-0.97	-6.3	-0.02
Mozambique	8.71	5.11	90,254,220,984	-0.21	0.65	-0.18	0.65	-5.17	0.461	-1.66	-18.7	-0.66
Samoa	4.26	2.11	2,038,189,444	-0.22	0.00	-0.23	0.65	-5.17	0.702	-0.11	-13.8	-0.79
Eswatini	7.61	4.37	4,442,875,788	-0.22	0.65	-0.23	0.65	-5.17	0.461	-4.61	-26.5	-1.73
New Caledonia	6.23	3.43	9,620,000,000	-0.21	0.00	-0.23	0.65	-5.17	0.461	-4.61	-21.5	-1.9

TABLE 10: APPENDIX ITEM E

F APPENDIX ITEM: SUMMARY OF NON-MATERIALIST RESILIENCE THEMES, EXAMPLES AND RELATED DISCOURSES

Type	Why?	Example	Linkov Matrix Factors	Related Discourses
Democratic transparency	Findings from anticipatory governance (Boyd & Wilson) stress that transparency should be a presumption, not classified or secretive preparations, to ensure that necessary mitigation and adaptation can be undertaken across society; and that updates and new evidence can be dispersed quickly.	Contrast transparency with CCP approach to Covid-19 in early stages, leading to greater spread than might have been if Doctors were listened to rather than suppressed.	Absorb; Adapt	Historical institutionalism. Normative institutionalism. Traditional Institutionalism. Upstream vs. downstream deliberative democracy.
Epistemic institutions	Ensuring the sciences are well integrated, so that crucial information and updating can occur in a timely manner. Also, it feeds into research and development needed to advance technologies that are pivotal to transitions, adaptations, and mitigations away from risk exposure.	Horizon scanning or other such means to identify emerging threats to build resilience against; or solution scans, to develop strategies to respond to such trends. Transdisciplinary FROs.	Adapt	Evidence-based/evidence-informed policy. Evidence-based policy or policy-based evidence? Organisational policy capacity.
R&D	As a component of a growth or post-growth economy, research and development will remain key for living standard enhancing or maintaining interventions, in the face of catastrophe or risks of catastrophe.	Supercapacitors for renewable energy storage, nuclear fusion, etc. to address the macro-trends of climate disruption.	Plan; Absorb; Recover; Adapt	
Social trust	High trust societies, perhaps hard to rigorously 'measure' are nevertheless theoretically seen to sustain welfare systems and social mutual support networks more easily. This helps on average avoid atomistic defections from norms that centre support and compassion for the vulnerable.	Nordic countries, neighbourhood mutualist networks during Covid-19, etc.	Plan; Absorb	Collective Leadership. Systemic Policy Capacity. Civil society.
Wellbeing economics		Measuring what matters - Jim Chalmers Mark Fabian - A Theory of Subjective Wellbeing Local Resilience Forum	Plan; Absorb; Recover; Adapt	Intergenerational fairness. Systems thinking in policymaking. Effects of reciprocity.

TABLE 11: APPENDIX ITEM F

G APPENDIX ITEM: APPLIED CLA CASE STUDY: EXTREME HEAT GOVERNANCE FUTURES IN SYDNEY

	Status Quo	The Chasm	'Big Society'	Turning Down the Heat
Litany	Siloed government, focused on administrative business-as-usual functions with limited connection between systemic and organisational policy capacity.	Strong local public services and a reduction in administrative siloes in local government, but a disconnect with local community needs, including civil society, hence minimising opportunities for agile bottom-up governance.	Community and civil society actors develop a robust 'bottom-up', decentralised and distributed response to extreme heat governance, using network governance to its maximum, regardless of local public services.	Local governments and civil society join forces to enable top-down and bottom-up implementation of extreme heat governance, breaking down administrative siloes and empowering each others' strengths in a collaborative, agile fashion.
Systemic	Local governments must maintain the business-as-usual to avoid risk and upset within the organisations. Political motivations and electoral cycles decide policy priorities, creating reactive as opposed to proactive policymaking.	Local governments and bureaucracies are primary actors in extreme heat governance, seeing themselves as top-down, coordinating actors. However, a systemic authorising environment has not been established among society-at-large, including civil society and community stakeholders.	Society understands, and even condemns, the lacklustre will, capacity and resources of local governments to coordinate extreme heat. There is a disconnect and even mistrust of government, but this motivates the social connections and civil society actors to conduct extreme heat governance.	Mutual trust, understanding and collaboration between local governments and their constituents, and joint objectives are understood and appreciated.
Worldview	Between a rock and a hard place.	Government knows best.	Personal responsibility.	All in this together.
Metaphor	Titanic avoiding the iceberg.	Puppet strings.	Frontier town.	Matching puzzle pieces.

TABLE 12: APPENDIX ITEM G

H GLOSSARY

Term	Definition
Abrupt Sunlight Reduction Scenarios (ASRS)	Scenarios in which sunlight is significantly blocked from reaching Earth's surface, often due to events like nuclear war (nuclear winter), volcanic eruptions, or asteroid impacts.
Causal Layered Analysis (CLA) incasting	A futures methodology that analyses issues on four levels—litany, systemic causes, worldview, and myth/metaphor— overlaid with double variable scenario mapping.
Change Progression Scenario (CPS) Method	A scenario-building tool that outlines processual scenarios of a complex issue, analysed using Litany, Systemic, Worldview and Metaphor.
City Resilience Framework	A tool developed by Arup with the Rockefeller Foundation to help cities understand and assess the complex and interrelated shocks and stresses that affect urban areas.
Civilisational collapse	The drastic decline or complete disintegration of human civilisations, often involving the breakdown of governance, economy, infrastructure, and population.
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. It may prove helpful to think of this as 'Risk of Collapse + GCR + Extinction' cumulatively.
Cognitive-affective	Relating to both cognitive (thinking) and affective (emotional) processes that influence human decision-making and behavior.
Complexity science	An interdisciplinary field studying complex systems and the emergent behavior of interconnected elements, often applied to ecosystems, economies, and societies.
Computable General Equilibrium	A type of economic model that simulates how economies respond to changes in policy, technology, or other external factors by solving for equilibrium across markets.
Decision-making Under Deep Uncertainty (DMDU)	An approach for making decisions when future conditions or system behaviours are unknown or highly unpredictable, necessitating reflexive thinking and anticipation of a plurality of futures.
Disciplinary governmentality	A form of governance that operates through the regulation of individual behaviour, often by internalising norms and expectations through institutions like schools, prisons, and bureaucracies.

Term	Definition
Durable totalitarianism	A form of authoritarian rule that is highly resilient and capable of persisting over long periods, often through surveillance, propaganda, and repression.
Dynamic Stochastic General Equilibrium	A macroeconomic model that explains aggregate economic phenomena using microeconomic principles, accounting for random shocks over time.
Ecological carrying capacity	The maximum population size of a species that an environment can sustain indefinitely without degrading the ecosystem.
Epistemic Institutions	Institutions that society relies upon to provide empirical evidence-based evidence to inform government and organisational decision-making.
Epistemic robustness	The strength of knowledge claims based on the consistency, reliability, and diversity of supporting evidence or reasoning across perspectives.
Global adaptive capacity	The ability of global systems - such as ecological, social, or political networks - to adjust to changes, resist shocks, and recover from disturbances.
Global Catastrophic Risks	Events or processes that could inflict serious harm on a global scale, potentially threatening the future of humanity.
Harmonised System (HS) Codes	An internationally standardised system of names and numbers for classifying traded products, maintained by the World Customs Organisation.
Hegemonic statist powers	States that exert dominant influence over global or regional politics and economics, often through military, financial, or ideological means.
High-altitude nuclear electromagnetic pulse (HEMP)	A burst of electromagnetic radiation from a nuclear explosion at high altitude, capable of disabling electronics and power grids over large areas.
Higher order systems	Complex systems that encompass or emerge from lower-level subsystems, often with additional layers of regulation, coordination, or abstraction.
Historical institutionalism	An approach to understanding institutions through the lens of historical development and path dependence, emphasizing how past decisions shape current outcomes.
Human Development Index	A composite statistic by the UN measuring a country's development through life expectancy, education, and income per capita.
Issue drivers	The underlying causes, not necessarily seen or visible, that result in particular issues manifesting or being exacerbated.
Litany	The surface-level, often media-driven presentation of problems without analysis of underlying causes; one of the four levels in Causal Layered Analysis.
Logistics Performance Index	An index created by the World Bank to measure the efficiency and quality of trade logistics in countries.

Term	Definition
Multi-stakeholder polycentric governance	A decentralised form of governance involving multiple actors (e.g., governments, NGOs, businesses) coordinating across overlapping jurisdictions. This contrasts with monocentric governance, which limits governance control to one central actor.
Neoliberal economic orthodoxy	A dominant economic philosophy emphasising free markets, deregulation, privatization, and reduced government intervention in the economy.
Network Centric Warfare doctrine	A military strategy that uses networked communications and information technology to improve situational awareness and coordination among armed forces.
Networked governance	A mode of governing characterised by horizontal, collaborative relationships among a variety of actors across public, private, and civil sectors.
New institutionalism	A theoretical framework in political science and sociology that emphasises the role of institutions in shaping behavior, culture, and outcomes.
Nodes of persisting complexity	Regions, institutions, or systems that maintain structural and functional complexity even when broader systems degrade.
Nodes of persisting recovery	Places or systems that retain the capacity to recover from shocks and support regeneration, even amid widespread collapse.
Normative institutionalism	An institutionalist approach that focuses on how institutional norms and values shape the behavior of actors.
Odyssean Process	A metaphor for adaptive, recursive, and systems-aware processes of governance or foresight that navigate complex and evolving conditions.
Political nous	Practical political intelligence or savvy; the ability to navigate political contexts effectively.
Prioritarian	An ethical principle giving priority to improving the well-being of those who are worst off.
Processing tracing	A qualitative research method that investigates the decision-making process by tracking evidence and sequences of events within a case.
Prolonged stagnation	A scenario where economic, technological, or social progress slows significantly over an extended period, impeding growth and innovation.
Rational choice institutionalism	A theory that explains institutional behavior based on rational actors making strategic decisions within institutional constraints.
Resilient Cities Network	A global network of cities dedicated to building resilience to physical, social, and economic challenges.
Revealed Comparative Analysis	An analytical approach that infers comparative advantage from observed trade patterns or resource allocations.

Term	Definition
Root Cause Analysis	A method for identifying the underlying causes of problems or incidents to prevent recurrence.
Shared Socio-economic Pathways (SSPs)	Scenarios developed for climate research that explore different global development trajectories and their implications for mitigation and adaptation.
Socialist governmentality	A form of governance focused on collective ownership, central planning, and the regulation of social life in line with socialist ideology.
Socio-ecological commons	Shared ecological resources and social systems that are co-managed by communities or collectives for mutual benefit.
Sociological institutionalism	A perspective that sees institutions as deeply embedded in social and cultural contexts, influencing behavior through norms and cognitive scripts.
System degrading catastrophes	Catastrophic events that cause long-term damage to critical systems such as ecosystems, infrastructure, or governance structures.
Trade entrepôt	A commercial centre or port where goods are imported, stored, and re-exported, often serving as a hub in global trade.
Traditional institutionalism	An early view of institutions emphasizing formal rules, structures, and legal frameworks in shaping political behavior.
Wellbeing economics	An economic paradigm that prioritizes human and ecological well-being over traditional indicators like GDP.
Wellbeing Economy Governments	A group of countries committed to advancing economic policies that prioritize well-being and sustainability over narrow growth metrics.
Wicked problems	Problems that are complex, interconnected, and difficult to define or solve definitively, often involving conflicting values and uncertain outcomes.
x-risk	Existential risk; a type of risk that could cause human extinction or permanently curtail humanity's potential.

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