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All-Hazards Policy for Global Catastrophic Risk

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Global Catastrophic Risk Institute Technical Report 23-1

2 November 2023

Cite as: Rumtin Sepasspour, 2023. All-Hazards Policy for Global Catastrophic Risk. Global Catastrophic Risk Institute Technical Report 23-1.

Executive Summary

A variety of threats could cause catastrophic harm to humanity globally. The list of threats include, but are not limited to, nuclear weapons, climate change, pandemics, asteroids and comets, supervolcanic eruption and ecological collapse. Although each threat has distinctive characteristics, they are not unrelated or mutually exclusive.

An all-hazards approach to global catastrophic risk (GCR) addresses GCR as a whole. An all-hazards policy approach provides a strategic policy framework to reducing GCR. It helps reduce multiple threats and hazards at the same time. It also helps tackle threats that are unknown or underestimated. Ultimately, all-hazards GCR policy will enable more efficient, effective and holistic reduction of GCR compared to treating the threats and hazards separately.

This report introduces the concept of all-hazards GCR and applies it to government policy for reducing GCR. It presents two approaches to all-hazards GCR policy.

Overarching policy manages GCR as a set. These policies are those efforts that govern, understand, prevent, prepare for, respond to, communicate about, and collaborate on GCR. For example, overarching policies could include risk assessment, monitoring and warning protocols, reducing drivers of GCR, planning and resilience, disaster response and recovery, and public communications.

Cross-cutting policy addresses issues that intersect with multiple threats and hazards. Cross-cutting policy areas include international relations and foreign policy; politics and governance; security and defense; economics and finance; natural resources and the environment; infrastructure and the built environment; health and healthcare; knowledge and information; technology and innovation; and society and culture. These areas are broader than GCR, but addressing how they intersect with GCR could be useful for reducing GCR.

The report's primary recommendations are:

- ***GCR experts*** should study all-hazard GCR and its policy implications. Additionally, they should identify and study risk drivers and factors, which are those conditions that lead to or exacerbate GCR.

- ***GCR research organizations and funders*** should provide dedicated support for all-hazards GCR policy. This support would include funding and analytical resourcing.

- ***GCR policy advocates*** should demand more all-hazards GCR policy research from the expert community. They should develop all-hazards GCR policy options for policymakers.

- ***Policymakers*** should develop all-hazards GCR policy and engage with the GCR expert community to formulate these policies.

Author Biography

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Acknowledgments

Rumtin Sepasspour is grateful to Seth Baum for extensive guidance, engagement and patience through the development of this report. Sepasspour's work on this report was funded by the Global Catastrophic Risk Institute.

Sepasspour dedicates this report to the memory of Nathan Sears (1987-2023), a leading researcher at the intersection of global catastrophic risk and international relations.

Introduction

This report develops the concept of all-hazards policy for global catastrophic risk (GCR). It provides a framework for understanding and developing all-hazards GCR policy. This framework aims to support policy research and development by GCR researchers, policy advocates and policymakers.

This report is, to the best of the author's knowledge, the first to develop an all-hazards policy framework for GCR. Some prior work has developed policy concepts that pertain to multiple global catastrophic threats. The report synthesizes this literature and incorporates it into a new systematic framework for all-hazards GCR policy.

All-hazards policy addresses a set of hazards collectively. It uses similarities, linkages and relationships between different threats and hazards to develop a more effective, efficient and holistic policy compared to addressing each separately. The framework developed in this report encompasses the full set of GCR. But the application of the framework does not necessarily mean that a government policy or action is applicable to every possible hazard. It will, in some instances, address some, not all, global catastrophic threats.

This report is important for the field that studies GCR. As an integrated field, it should distinguish between the efforts for specific threats and hazards as opposed to GCR as a whole. This report will also be important for policy entrepreneurs and advocates that are looking to successfully influence policy on GCR. They can use an all-hazard approach to identify a broader range of policy options to reduce GCR and better engage policymaking beyond the specific threats.

An all-hazards approach to global catastrophic risk

Global catastrophic risk (GCR) refers to the potential for certain threats or hazards to inflict significant damage to human wellbeing on a global scale.[1] GCR is a function of two components. First, it requires threats and hazards with the potential for global impact. Second, it requires vulnerable human and societal systems that, if collapsed, would result in catastrophic consequences. Some researchers have defined the risk by minimum damage thresholds, such as the proportion of global population that is killed. Others have measured the scale by qualitative judgments that relate to the foregoing of human progress or flourishing.[2]

The precise definition of GCR remains a topic of discussion within the academic field that studies the risk. The same also applies to the related concept of existential risk. Any distinction between the two terms is not crucial for this report.[3] For the sake of simplicity, the report uses global catastrophic risk or GCR as a collective term for the risk that humanity is harmed on a mass, global, and potentially irreversible, scale.

The global catastrophic threats and hazards

An all-hazards approach to GCR benefits from first identifying the specific threats and hazards. There is no single definitive list due to the disagreement over how to define GCR and uncertainty about what could cause GCR. Nonetheless, listing the key threats and hazards is useful.

A set of threats and hazards can be developed by considering those identified and analyzed in the 31 books and 7 reports that seek to comprehensively study GCR (see Appendix 1). Of all the threats and hazards that are identified as being potentially globally catastrophic, a subset appears frequently across these studies. It represents a loose consensus of those that constitute sources of GCR:

- Artificial Intelligence (AI)
- Biotechnology
- Climate change
- Ecological collapse
- Near-Earth objects, such as asteroids and comets
- Nuclear weapons
- Pandemics
- Supervolcanic eruption

This list should not be regarded as correct, definitive, complete, agreed or ranked. It excludes certain potential sources of GCR that some studies identify. And threats and hazards are not the only component of GCR. More detailed discussion is presented in Appendix 1.

All-hazards GCR research

A key problem with viewing GCR as separate, unrelated or mutually exclusive threats and hazards is that it misses important research opportunities to better understand GCR as a whole. In contrast, an all-hazards approach to GCR research offers several advantages.

First, an all-hazards GCR research facilitates the development and application of common methods and frameworks across GCR.[4] The sources of GCR share common scientific, analytical and ethical challenges. The lessons and approaches from one threat or hazard can be more effectively transferred to others. The all-hazards approach therefore also fosters multidisciplinary perspectives, which helps lead to innovative approaches and insights.

Second, an all-hazards GCR research enables a more holistic and integrated study of GCR. It can identify and explore the interconnections, similarities, relationships and shared characteristics across the sources of GCR. This includes: shared risk factors, in which the same phenomenon can amplify multiple sources of GCR; risk cascades, in which the occurrence of one type of global catastrophe can cause the occurrence of another type; risk convergence, in which the combination of two or more threats and hazards creates a different or new risk; and risk interventions, in which individual actions affect multiple sources of GCR. This integrated view also enables efforts to compare and prioritize between the various threats and hazards.

Third, all-hazards GCR research can increase the amount of attention and resources going to each GCR, and GCR as a whole. It helps overcome or resolve gaps and challenges that arise when studying the specific threats in their separate domains. By viewing GCR collectively, the study of the extreme end of individual threats can receive more attention and resources. For example, catastrophic climate change or nuclear winter scenarios are not areas of heavy focus in their respective fields.[5] An all-hazards GCR research program serves as a platform to pursue more resources for GCR research. It also legitimizes the study of the risk in the eyes of funders, academia, the public, media, private sector and policymakers.

Several research studies provide frameworks to understanding GCR more holistically. Hin-Yan Liu, Kristian Lauta and Matthijs Maas outline in their piece on ‘boring apocalypses’ that GCR is a function of threat or hazard as well as vulnerability and exposure.[6] Researchers from the Centre for the Study of Existential Risk (CSER) break GCR down into three key components: a critical system or systems whose safety boundaries are breached by a potential threat; the mechanisms by which this threat might spread globally; and the manner in which humanity might fail to prevent or mitigate both.[7] Owen Cotton-Barratt, Max Daniel and Anders Sandberg develop a three-layers-of-defense approach to explaining and reducing GCR: preventing a risk from originating, responding before it scales globally, and building resilience in humanity against extinction.[8]

These frameworks are useful analytically but require further development for a policy context.

All-hazards GCR policy

Governments are critical risk managers for their jurisdictions. The risk being managed could cover a wide range of threats, such natural hazards, malicious actors and economic turmoil. An all-hazards approach to managing risk, particularly for emergencies and disasters, has become a relatively standard policy for national governments.[9]

For example, the US National Preparedness Goal emphasizes “the need for an all-hazards, capability-based approach to preparedness planning”.[10] Countries that conduct national risk

assessments, such as the United Kingdom or Canada, aim for an all-hazards assessment in order to identify, analyze and prioritize the full range of potential threats and hazards.[11] Many governments focus on the protection of critical infrastructure – such as energy or telecommunication systems – because it could be impacted by a variety of nationally significant threats and hazards.[12]

The all-hazards approach taken by governments does not necessarily mean that a government policy or action is applicable to every possible hazard. Rather, it means that the government is strategically managing the full range of potential risk and addressing commonalities between many kinds of risk. Governments that take this approach see all-hazards policy as a more efficient use of resources. It also ensures government departments coordinate between each other to effectively manage emergencies. A review of the all-hazards approach to emergency management stated that it was highly effective because "it is cost-effective, provides an excellent framework for responding to disasters, is hands-on, and encourages cooperation between non-profits, businesses, communities, and various levels of government."[13]

Governments commonly use an all-hazards approach for disaster risk management.[14] Furthermore, the approach is mainly applied for risk assessment and risk planning, not necessarily all the steps in a risk management process. Regardless of its current specific use, the same concept is useful for GCR management. By using an all-hazards policy approach to GCR, policymakers derive several benefits.

First, an all-hazards approach provides a strategic policy framework to reducing GCR. It provides governments and societies a holistic view of risk reduction efforts, which helps identify gaps in policy as well as linkages between different policies. Policy aimed at reducing specific threats and hazards would sit in this framework. The all-hazards policy approach can therefore support governments to better prioritize and coordinate policies.

Second, an all-hazards approach supports policy development to address multiple threats and hazards. These policies could reduce the possibility that multiple threats and hazards from occurring, or increase humanity's ability to deal with a catastrophe. All-hazards policy can therefore be a more efficient use of government resources.

Third, an all-hazards approach is a way to tackle unknown threats. As technological and scientific discovery continues, humanity could uncover new pathways to catastrophe. By definition, policy cannot be designed specifically to reduce unknown threats. All-hazards policy could reduce this risk before the specific threats are created or identified.

Finally, an all-hazards approach acts as failsafe if the known threats are not prioritized or assessed properly. Mistaken or poor judgments is likely when GCR is so susceptible to uncertainty and complexity.[15] All-hazards policy can ensure that governments address threats that should have been prioritized.

This report provides two frameworks for all-hazards GCR policy: *overarching* and *cross-cutting*.

Overarching policy for GCR

Overarching policies to reduce GCR are defined as being those efforts by government that address the entire set of threats and hazard capable of producing globally catastrophic consequences. Overarching policy can include policy settings, regulations, strategies, frameworks, guidance or activities by the government that encompass GCR as a whole. Overarching policies are not targeted at a specific threat or hazard. But they may enable subsequent government activities to do so.

This conception of "overarching" risk policy is new to this report. Existing operational and disaster risk management use similar concepts, such as assessment, treatment, prevention, mitigation, preparedness, response, rehabilitation and recovery.[16] Indeed, this framework can be used for the management of any type of risk, not just GCR.

Overarching policy is comprised of seven categories: govern, understand, prevent, prepare, respond, communicate and collaborate (see figure 1).[17] This section will provide further explanation and examples for each of these categories and how they relate to managing GCR.

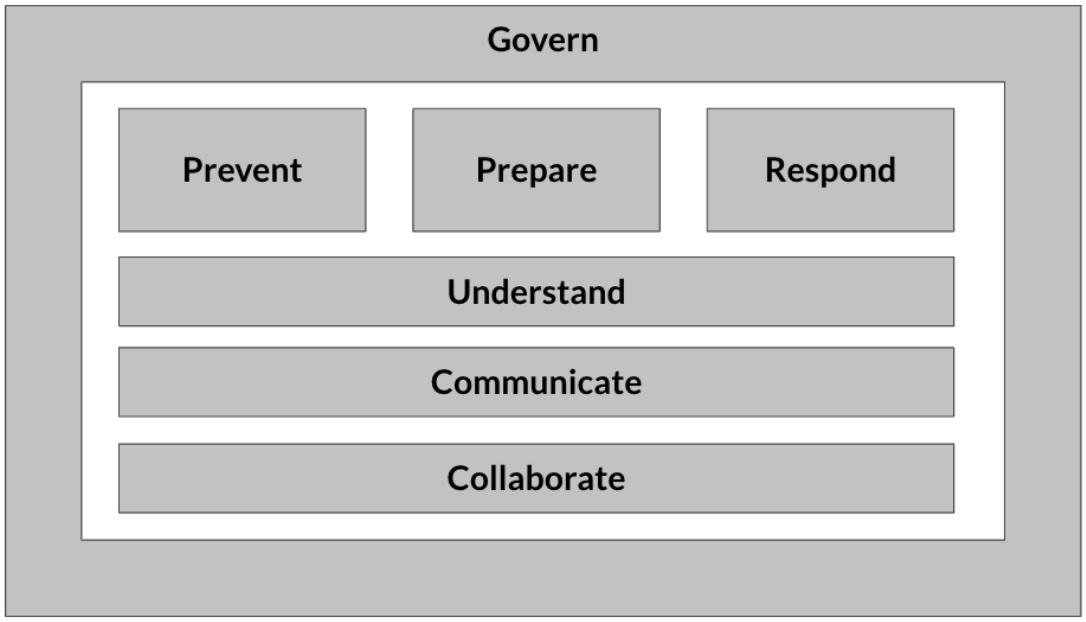

Figure 1: Overarching GCR policy framework

Govern

Addressing GCR as a whole requires the governance arrangements that guide, coordinate and inform the specific actions that government intend to take.[18] Risk governance does not directly reduce risk – rather, it attempts to organize the functions of government so that risk reduction efforts are more likely to succeed. Risk governance includes architecture and institutional design, policy guidance and strategic planning, personnel and culture, decision-making processes, and monitoring and evaluation of implementation.

Some prior GCR research has noted the need for risk governance due to the complexity of GCR and the lack of governance arrangements. Julia Kreienkamp and Tom Pegram outline principles for designing governance for GCR.[19] Len Fisher and Anders Sandberg look at the necessary and enabling conditions for the governance of GCR.[20]

In some instances, GCR experts have made specific recommendations for improving risk governance. Extreme risk researchers in the UK have suggested stronger risk management practices by the UK government, including the appointment of a national Chief Risk Officer and a National Extreme Risks Institute.[21] The UK House of Lords Special Select Committee on Risk Assessment and Risk Planning also suggested improvements to the UK's risk efforts to better consider extreme risk.[22] Catastrophic risk researchers Matt Boyd and Nick Wilson make similar recommendations for a New Zealand policy context.[23] Risk governance could also be developed at the global level.[24]

Understand

Governments can take actions that improve their understanding of GCR. Understanding GCR requires efforts to identify study, analyze, assess, monitor or warn about the risk.[25] GCR is a difficult analytical problem and many elements of it still need to be explored.[26] A better understanding would help inform the actions that will directly reduce GCR.

As a starting point, governments could implement processes that help them better assess GCR holistically. National risk assessments, for example, are a function many governments perform to understand nationally significant risk. But these processes have come under scrutiny since the onset of COVID-19 because they do not adequately cover extreme risk.[27] In the US, the Global Catastrophic Risk Management Act specifically calls for an assessment of existential and global catastrophic risk.[28]

Intelligence and warning capability are tools of government for understanding threats to the nation. Intelligence collection and analysis capability could help to detect, analyze and warn senior policymakers of global catastrophic threats.[29] Richard Clarke and RP Eddy, two former senior national security officials, have recommended a National Warning Office within the White House, which could play an important role for emerging risks and catastrophic crises.[30]

Futures and foresight capabilities within government could alert policymakers to emerging issues and facilitate better long-term policy. Used in conjunction with risk assessment efforts, these capabilities can help identify emerging risk, explore future scenarios and reduce uncertainty. GCR research has commonly used and recommended these futures and foresight techniques – such as horizon-scanning, scenario-building, forecasting competitions and red-teaming.[31] Some governments already have futures functions, such as Canada's Policy Horizons unit, Singapore's Centre for Strategic Futures, the UK Government Office for Science's Futures team and Finland's Government Foresight Group.

Some GCR research has also suggested that governments increase their access to science and research capability on GCR so that policy problems and solutions are supported by cutting-edge

technical expertise. This could be achieved by governments developing in-house science and research on GCR. For example, GCR researchers proposed that the UK's new research funding agency should include a focus on GCR.[32] Governments could also improve linkages between academia and policy. Funding academic research in this space is a simple method. Collaborating and engaging directly could be more meaningful, however. For example, the Alan Turning Institute and CSER worked directly with the UK's defense research arm, Defence Science and Technology Laboratory (DSTL), to jointly produce a report on 'epistemic security'.[33]

Prevent

Preventing GCR requires making it less likely or even impossible for the threats or hazards to exist or be realized.[34] Governments have a variety of opportunities to prevent global catastrophes from occurring or at least to make it less likely that global catastrophes would occur. Some of these opportunities are threat- or hazard-specific, such as programs to detect and possibly deflect Earth-bound asteroids in our solar system, reduce accidental or deliberate use of nuclear weapons, or slow or halt the unfettered development of advanced artificial intelligence systems. Other opportunities address multiple threats or hazards by targeting the structural or systemic characteristics that lead to or exacerbate GCR.

The two avenues for preventing all-hazard GCR are addressing risk factors and risk drivers. Risk factor is a term often used in health and medicine to mean the attributes, characteristics or exposures that increase the likelihood of a person developing a disease, injury or health condition.[35] Risk driver is a less commonly used term.[36] It refers to underlying causes that give rise to a threat or hazard.[37] Without a driver, there would be no risk; without a factor, the risk would be smaller.[38] In other words, drivers cause risk, factors increase it. By treating drivers of risk, governments might prevent underlying causes that lead to multiple threats and hazards. By treating risk factors, governments can reduce the dynamics that make a global catastrophe more likely.

At this stage, GCR experts have conducted very limited study on the risk factors or drivers of GCR and made few policy recommendations. No set of risk drivers or factors has been identified, analyzed or agreed. But some initial discussion has laid the ground. Toby Ord has a short section in *The Precipice* on risk factors, including a mathematical approach to understanding how a risk factor increases the risk.[39] Owen Cotton-Barratt, Max Daniel and Anders Sandberg address the importance of risk factors, which they define as "events or structural conditions that may weaken the defense layers even without posing a risk of immediate extinction themselves".[40] Both publications recommend further research to identify the major risk factors but admit to a lack of focus. This further work would help clarify the concepts of risk driver and risk factor in a GCR context.

Prepare

Risk preparedness is the set of the measures taken to reduce the vulnerability to a threat or hazard.[41] Vulnerability is defined as the features or attributes of a system that increase its susceptibility of potential harm to a threat or hazard.[42] As defined here, efforts to reduce vulnerability would reduce the consequence or severity of risk, but not the probability. By

considering the vulnerability side of the risk equation, policymakers can better focus on the political, social, cultural and institutional weaknesses that make a threat or hazard potentially catastrophic.[43] Strategies that build preparedness and resilience can help with multiple or all global catastrophic threats and hazards, particularly when specific scenarios for GCR are highly uncertain.[44]

GCR researchers have recognized preparedness and resilience as an important focus for risk reduction efforts. For example, CSER's submission to the UK's National Resilience Strategy notes that all-hazard policy is an important part of building resilience to GCR.[45] According to another paper, "preparing for disaster response and recovery" is one of the three strategies to manage the risk from emerging technologies.[46] Certain countries, such as island nations, and other types of "refuges", such as isolated bunkers or submarines, could be more resilient to global catastrophe.[47] Protecting or building these refuges could mean that a global catastrophe does not become existential to humanity.

Resilience of the food system is one of the more well-researched all-hazard approaches with direct policy relevance. The Alliance to Feed the Earth in Disasters (ALLFED) has published extensively on alternative foods as a critical element of preparedness for global catastrophe.[48] A CSER researcher has also urged policymakers to consider future foods as an option for both malnutrition and resilience to systemic risk.[49] And CSER affiliate Sam Hilton and ALLFED researcher Sahil Shah proposed that the UK national risk register consider food shortages as a key risk.[50]

Respond

Risk response is the set of actions taken during and immediately after a risk event in order to reduce its impact and to recover.[51] These actions are distinct to preparedness, which are taken in anticipation of risk. Preparedness activities can be operationalized in the response phase. There has been almost no scholarship on this phase of a global catastrophe or its policy implications and aspects. Lewis Dartnell's book "The Knowledge: How to Rebuild Civilization in the Aftermath of a Cataclysm" is the only prominent investigation of what actions humanity will have to take in direct response to a catastrophe.[52] Haydn Belfield investigates a range of recovery paths from civilizational collapse.[53] The response phase should also consider how governments and societies intend to rebuild their political, economic, societal and infrastructure systems as quickly and effectively as possible.

Communicate

Risk communications are activities to share or exchange information and conduct dialogue with stakeholders about risk management.[54] Improving risk communications procedures could help the public contribute to GCR reduction and be positioned to respond should it occur. Proactive yet careful communications can alert citizens to GCR and spur action.[55]

Poor communication could hamper risk reduction efforts. It could lead to cynicism, misunderstandings, and undermine trust in experts and the government.[56] Laypeople could mistake explicit expressions of uncertainty for evasiveness or equivocation, or misinterpret

likelihood and probabilistic statements.[57] It could also lead to fear or apathy in the populace, which might not be conducive to whole-of-society efforts to managing GCR.

Risk communications is a well-established area of study, and there are numerous resources for policymakers on communicating with the public about risk, uncertainty and evidence.[58] However, the field of GCR studies has so far conducted very little policy work around GCR communications.[59] The Swedish Governments pamphlet *If Crisis or War Comes* is a promising example of governments engaging with their citizens on national crises.[60]

Collaborate

Finally, risk collaboration are those mechanisms that enable governments to coordinate and engage with stakeholders. It could be important in sharing information and lessons, and driving collective action. Many sources of GCR arise outside of governments' control; risk can arise from actions taken by corporations, other governments or potentially individuals. So national governments must collaborate with stakeholders, including private sector, civil society, academic, other countries and international organizations, to manage the risk.

Collaboration with other governments is particularly vital so that there is shared ownership and action on the risks. International or multilateral action could be important policy for GCR.[61] This collaboration stage of GCR management is not intended to cover the global governance regimes that might be useful for GCR. This stage is aimed at the actions that national governments can take on the global stage, including in their bilateral or regional relationships.

There remain few policy ideas for how governments could collaborate to reduce risk. In one example, UK-based risk researchers proposed that the UK should lead global efforts around risk management and GCR.[62] And there might regional or 'minilateral' – smaller issue-based partnerships between countries – mechanisms to collaborate on risk reduction that does not require entirely new global-level efforts. For example, one researcher proposes "coalitions of the obligated" for GCR in absence of more formal or global governance regimes.[63]

Cross-cutting policy for GCR

Cross-cutting policies arise from broad policy domains relevant for multiple threats and hazards.[64] In general, these policy domains – such as international relations, national security, economics, food, technology, natural resources and infrastructure – are not exclusively related to GCR. Governments mostly focus on them without regard to or recognition of GCR. Addressing how the domains intersect with GCR could be a useful strategy for reducing the risk. A cross-cutting policy approach to GCR requires identifying what the cross-cutting domains are, understanding their relationships with GCR, and developing policies that address this relationship.

Cross-cutting policy for GCR includes both the impact of cross-cutting domains on GCR and the impact of GCR on those domains. For example, security or economic factors can, in various ways, lead to the risk that emerges from AI, climate change and weapons of mass destruction. On the other hand, a globally catastrophic scenario would be severely harmful to national security and economies. Food is a highly cross-cutting issue because food systems contribute to climate change via greenhouse gas emissions, biodiversity loss through land clearing, and naturally occurring pandemics via zoonosis. Food systems are also vulnerable to global catastrophe scenarios. Climate change and abrupt sun-blocking scenarios, such as nuclear or volcanic winter, could greatly and suddenly reduce global food supplies.

GCR studies has conducted some, but very limited, research and analysis on cross-cutting issues. Food systems, mostly resilience to catastrophes, is the main exception.[65] There have not been any attempts to systematically identify and characterize cross-cutting domains for GCR. Additionally, the term “cross-cutting” and related terms are not widely used or accepted as relating to GCR.[66] And so the cross-cutting policy domains relevant for GCR remain unclear and undefined. By extension, few cross-cutting policy ideas have been developed for GCR.

The types of issue that could be considered cross-cutting have been raised in various academic papers on GCR. In the Avin et al. paper on “Classifying global catastrophic risks”, CSER researchers identify multiple critical systems that are critical for humanity’s ability to survive: climate control, food, health, resource extraction, security, shelter and utilities.[67] The contribution of Hin-Yan Liu, Kristian Lauta, and Matthijs Maas touches on some cross-cutting issues, such as: energy and resource inputs, biology, governance and institutions, infrastructure, and culture and society. In a Cascade Institute paper on “Global Polycrisis”, the authors list the eight functional systems that operate at the global scale: economy; health; social order and governance; food; international security; energy; environment; transport and communications.[68]

This report provides a new taxonomy for cross-cutting domains relevant for GCR (see Figure 2).[69] The following sections provides a high-level outline for each of these cross-cutting domains and how they might relate to GCR.

Figure 2: Cross-cutting domains for GCR

International relations and foreign policy

International relations (IR) and foreign policy represents the interaction between countries and with other groups, such as non-state actors and multilateral organizations, in a global setting. States compete and cooperate across all domains – geographic, diplomatic, military, economic, energy, environmental, technological and cultural – to advance their national interests, including their values.

Relations between states directly contribute to some threats, such as great power conflict, the production and use of nuclear weapons and other weapons of mass destruction, and AI risk. The geopolitical context also shapes how countries cooperate to reduce risk. Where multilateral solutions are required to reduce GCR, foreign relations and policy will be instrumental. And should a catastrophe occur, IR will shape the response.

The current geopolitical environment is characterized by strategic competition, bordering on rivalry, between the US and China. Strategic competition increases GCR in a number of ways. It distracts, and potentially blinds, from the greater global threats. It incentivises a build-up in military and technological capabilities that could exacerbate risk. It reduces the opportunity and space for leader-level engagement that is critical to crisis management. And multilateral forums, which can provide constraints on behavior, are becoming their own domain of contest, reducing the opportunity for engagement.

How IR affects GCR as a whole has not been rigorously studied. Nathan Sears has pioneered some work on the intersection of IR theory and GCR.[70] Stephen Clare's report on great power conflict also provides useful analysis in this direction.[71] Efforts to view global governance regimes of GCR naturally sits within an IR context. For example, in a paper mapping the international governance of GCR, Luke Kemp and Catherine Rhodes find it fragmented and insufficient.[72] Any efforts to close these gaps and reform governance regimes cannot be separated from the geopolitical context. Where GCR research touches on foreign policy, it is typically in passing and on specific threats, such as nuclear war, AI, climate change and geoengineering.[73]

Politics and governance

Politics and governance are the systems, rules and structures by which groups of people operate to exercise authority. In general, these actors could be in formal organizations, such as international organizations, national governments and corporations. At a national level, elements of politics and governance – such as the political system and the legal system – cut across GCR.[74]

The political system and the model of governance can shape how GCR is handled. Different models, such as democracy, autocracy, oligarchy or monarchy, might take different approaches that exacerbate or reduce GCR. The governance model shapes how policymakers might consider the risk, how they develop and implement policy, which groups they consider in the policy process, how they interact with other countries, and how they engage their citizens.

A major criticism of democracies is their propensity for political short-termism. Policymakers and politicians tend to focus on current issues or short-term gains, potentially at the expense of longer-term considerations and consequences. This bias occurs for a range of reasons, including the electoral pressure, media cycles, lobbying pressure, lack of incentives to plan long term, and the natural human inclination to deprioritize uncertain, unlikely or future challenges.[75] Political short-termism could be a key factor that drives GCR.[76] Australian politician, Andrew Leigh, covers it extensively in his book, *What's the Worst that could Happen?*.[77] GCR researchers have looked at institutions and institutional provisions that better represent future generations in policy development and decision-making.[78] Another approach has sought to improve decision-making within organizations that are most relevant for GCR and other long-term issues.[79]

The legal system, both nationally and internationally, is a broad term that describes the processes for making, interpreting and enforcing laws. The legal system is relevant for all activities of societies and nations, and so will impact GCR in a variety of ways. However, without further research, it is unclear what those impacts are.[80] For example, legal systems might systematically disadvantage certain groups, such as future generations, or be unable to hold accountable groups that negligently create risk.

Security and defense

Security is fundamentally about survival and avoiding harm, and it implies the continuation of life. In a policy sense, security, and by extension, defense, refer to the protection and preservation of a jurisdiction's sovereignty and territorial integrity and the safety and wellbeing of its citizens.

The link between security and defense with GCR might seem self-evident. Security is a paradigm through which specific global catastrophic threats are viewed, such nuclear security, biosecurity and cybersecurity.[81] However, the field has not clearly or holistically articulated the policy implications of this cross-cutting issue. The 2023 edited volume "Existential Risks in Peace and Conflict Studies" presents a strong starting point for understanding the link holistically. Also helpful is Nathan Sears's work on "existential security", meaning a framework for the survival of humanity, building on the concept of national security.[82]

There are three broad ways that security and defense as a policy issue intersects with GCR.

The first, and most obvious way, is that that the scale of death and suffering of a global catastrophe would be incredibly high, which makes it, by definition, a security concern for nations and other jurisdictions. No matter how a global catastrophe arises, it would threaten social cohesion, political boundaries and human security. As COVID-19 showed, massive global disruptions can lead to internal political instability around the world and empower adversaries to sow discord and misinformation in the public

The second aspect is that GCR can arise from within the security domain. Both state and non-state actors around the world take measures to protect their security or defend their interests. This leads to defense and security establishments, as well as non-state actors with malicious intent, to create weapons systems that could cause harm on a massive scale. Nuclear weapons and bioweapons lead to catastrophic risk as a direct result of their security purpose. Artificial intelligence and other forms of advanced technologies could be used maliciously by nefarious actors, such as terrorists, rogue states and organized criminal actors.[83] And existing security threats are likely to be exacerbated if these actors could use AI to increase the scale, efficiency and speed of their attacks.

The third aspect is that certain capabilities of the national security community could be critical to managing and reducing GCR. National security communities – particularly defense, emergency management and intelligence – receive enormous funding and house some of governments' most advanced capabilities. National security investments and capabilities could be devoted to understanding GCR. And national security communities' planning and preparedness may be required to build the national resilience.

Recognizing security and defense as a cross-cutting issue does not require endorsing it as the most productive frame to understand or reduce GCR. Indeed, further work might be needed to understand the benefits and issues with a security framing.[84] However, the implications of security and defense issues on GCR means that it is an important topic for further investigation and potential policy work.

Economics and finance

Economics and finance refers to the processes by which economic actors produce, consume, distribute, exchange and allocate resources such as labor and capital. It encompasses the mechanisms through which this exchange takes place, and the incentives that motivate individuals, firms and governments to engage in the trade of goods and services.

There has been some study conducted on the economic aspects of GCR. Ilan Noy and Tomáš Uher survey the economic implications of solar flares, super-volcanoes, pandemics, and artificial intelligence.[85] They conclude that "it seems undeniable that [economists] are currently under-investing in thinking about these risks, not to say planning for them, or developing the systems that might be necessary to prevent some of the catastrophic scenarios described here from transpiring." Several papers have been written on the relationship between existential risk and economic growth.[86] Weitzman uses catastrophic climate change as a prototype for analyzing the economics of low-probability, high-impact catastrophes.[87] There is a large literature on the economics of catastrophes.[88] This literature covers a wider range of catastrophes and not just global catastrophes, but its analytical frameworks are applicable to GCR.

Several elements of the economic system are potentially important to GCR. Markets drive many of the incentives and negative externalities that shape risk. Market externalities such as waste and pollution are not captured in pricing but can lead to harms such as environmental damage and climate change. The economic competition in AI and biotechnology could lead to unsafe practices. Industrial policy can play a large role in pricing negative externalities, incentivizing safety and disincentivizing risk. Discount rates – used by economic actors like business and governments to value how benefits of a project should be assigned to the present as against the future – can affect decisions on risks that play out over different times.

Trade and supply chains are critical for survival. As Seth Baum states, "many GCRs could result in supply chain disruptions, due to some combination of damage to manufacturing facilities, suspension of shipping, and loss of labor."[89] The fragility of supply chains has been primarily driven by forces of globalization and efficiency-led just-in-time processes. Hoarding could be a dangerous public reaction should a catastrophe occur. Building resilience and redundancy in supply chains might require a different economic model and heavy government involvement.

The finance industry and financial instruments also intersect with GCR. Insurance markets could be mechanisms to provide financial support to those impacted by catastrophes. They also serve to internalize the potential cost for those that create risk.[90] Governments, particularly their treasury departments, might need to account for risk and disasters in their own budgets, given that the government is typically the insurer of last resort. And how financial transactions take place amid a catastrophe, especially if financial infrastructure is damaged, might be critical to the function of society.

Natural resources and the environment

Natural resources refer to the raw or naturally-occurring materials that are needed to maintain human and societal activities. Human survival depends on at least three critical natural resources: food, water and energy. In many catastrophe scenarios, the production, supply and security of food, water and energy might be critical to survival.

The food and water system encompasses the planting, irrigating, harvesting, storing, transporting, processing, delivering, selling, consuming and disposing of food, water and related items. Resilient food systems and food production after catastrophe has been one of the most studied cross-cutting issues in the field of GCR studies. For example, ALLFED is almost entirely focused on research and solutions that would increase resilience to global catastrophic food risk. The research in this space includes scenarios that would block out the sun and lead to agricultural collapse, as well as alternative foods that could survive or be scaled up in the aftermath of a catastrophe.[91] A paper by two academics from The Pennsylvania State University investigate the impact of sun-blocking catastrophes on forests, which provide food and fuel for over a billion people.[92] And the Svalbard Global Seed Vault represents a real-world example of food policy to prepare for catastrophe.[93]

The food system is not only subject to GCR, but also a driver of the risk. As CSER researcher Asaf Tzachor states, "the global system of food and agriculture is constrained by finite resources, it is prone to operational instability, it fails to prevent famine and micronutrient deficiencies, and it is a prime contributor to greenhouse gas emissions, climate change and ecosystems collapse. If left unattended, the system may engender further global catastrophic risks."[94]

Similar assessments around the water system, both as subject to risk and driver of risk, are missing. It receives scant attention and mostly passing mention. The most direct link between water and GCR was provided by Asha Asokan and Ira Helfand, who investigated how water scarcity, driven by climate change, might increase risk of nuclear catastrophe in South Asia.[95]

The energy system encompasses producing, marketing, storing and transporting fuels. These include fossil fuel energy sources such as coal, oil and gas, nuclear energy, and renewable energy sources such as solar energy, wind energy and hydroelectricity. Beyond energy's roles in climate change, the broader energy implications, drivers and impacts of GCR is not well understood or researched. For example, energy supply could be highly vulnerable to disruption from crises and catastrophes.[96]

A De Amorim et al. paper on the nexus of water, food and energy security in the context of global risk sets a strong example for further research investigating the impacts of natural resources on GCR.[97] Of the 30 risks identified in the World Economic Forum's Global Risks Report, 22 impacted food security, 16 impacted energy affordability and supply availability and 14 threatened water security. The paper also looked at the interaction of these three resource insecurities, and found that nine global risks could cause greatly impact the nexus between water, energy, and food. The paper showed that not only are individual resources impacted by global risk, but their interaction is complex and vulnerable as well. Similar research could be conducted on the three resources and their nexus for GCR.

Infrastructure and the built environment

Infrastructure and the built environment refers to the physical human-made structures, facilities and systems that a country or organization uses in order to work effectively. This includes residential and commercial buildings, transport infrastructure, such as roads, bridges and ports, and communications assets, such as satellites, cables and information technology systems.

Research on the infrastructure aspects of GCR remains limited, even in threat-specific domains. As James Scouras, in a piece on nuclear war as a GCR, states, "the physical consequences to the infrastructures that sustain societies [such as power or transportation] has never been a focus of nuclear weapons effects research."[98]

Infrastructure plays an important role in resilience to catastrophe. Ensuring critical infrastructure survives and functions will be relevant for a range of GCR scenarios. Energy grids, telecommunications and transport infrastructure are vulnerable in many countries, even to risk that is below GCR-level. And, should critical infrastructure fail, it could lead to or exacerbate catastrophic events. For example, Seth Baum and Anthony Barrett argue that human civilization could be threatened if key nodes in networks of physical infrastructure fail, such as transformers within electricity networks or ports within transportation networks.[99]

Infrastructure resilience has been referenced in threat-specific work, which is a starting point for a more all-hazards treatment. For example, in the context of volcanic eruptions, GCR researchers stated that "critical systems and infrastructures, such as shipping passages, submarine cables, and aerial transportation routes, are essential to sustain our societies and to ensure their continued development."[100] Edward Oughton has led multiple studies into the infrastructure failures due to space weather.[101] Researchers have also looked into the cost effectiveness of interventions into the loss of electricity, which could be a result of extreme solar storms, high-altitude electromagnetic pulses, and coordinated cyber-attacks.[102]

The increasingly technological inputs into infrastructure and the built environment create a source of vulnerability, particularly to the growing risk of AI and cyber.[103] Holistic assessments of how GCR could impact infrastructure are valuable exercises to develop shared understanding and provide potential possible responses. Again, to the extent that this work has been conducted, it remains threat specific. For example, in 2008, the EMP commission – established by US legislation – released its report on the vulnerability of the US to an electromagnetic pulse and its potential impact on critical infrastructure.[104]

Infrastructure-related solutions could also help prevent GCR. For example, building ventilation and disinfection systems could be an important mechanism for reducing the transmission of airborne pathogens.[105] More work would be required to identify how infrastructure could be used to prevent a range of threats and hazards.

Health and healthcare

Health is a broad term covering the physical and mental welfare of living organisms, particularly humans. Healthcare is the set of systems and institutions that maintain human and animal health.

It might be self-evident that health is a function of GCR – after all, human health is being threatened to the point of death on a global scale. Human health is harmed by GCR when the body is not able to withstand conditions that would deny it access to life-supporting inputs, such as oxygen and food, or cause grievous harm, such as diseases and toxins. The health system would be a key responder to GCR scenarios, so its resilience in a catastrophe is critical. Healthcare capabilities – such as emergency services, hospitals, medical and pharmaceutical production and distribution of healthcare products and services – are applicable to a range of catastrophic scenarios.

Despite the linkage between health and GCR, heath features little as a cross-cutting policy issue for all-hazards GCR. "Health" is one of the socio-technological systems in the CSER paper on classifying global catastrophic risk, though it does not receive any further explanation.[106] In a 2022 academic article, social science researchers suggest that healthcare ethics and guidelines for medical resources need to be revised for GCR.[107] In 2017, experts in global catastrophic biological risk noted the lack of overlap between the research communities that study health security and the GCR.[108] Indeed, the call needs to go wider – the health community and the GCR research community could collaborate further across the spectrum of risk.

Health certainly receives attention for some specific globally catastrophic threats and hazards. Pandemics, especially naturally occurring pandemics that often arise from poor health in humans and animals, is primarily a health issue. Nuclear war has direct health impacts and can be viewed through a health lens.[109] For example, Tilman Ruff, a global health expert and the co-founder of the International Campaign to Abolish Nuclear Weapons (ICAN), takes a public health perspective on nuclear war.[110]

And a large literature exists on the connection between health and climate change. However, there is little investigation of health impacts for catastrophic climate change. According to a literature review of 25 years of research relating to health and climate change, "most papers instead focused on infectious diseases, direct heat effects and other disciplinary-bounded phenomena and consequences."[111] In the context of geoengineering, stratospheric aerosol injection could "negatively impact human health by both changing disease vectors and range… and by undermining existing health system infrastructure."[112]

The healthcare system could itself be a source or exacerbator of risk. For example, the accidental release of pathogens from biological security laboratories is a key vector for pandemic risk. Gain-of-function research and virus hunting programs increase the potential of and exposure to viruses for which humans have little or no immunity. And antimicrobial resistance, which the excessive use of antibiotics has amplified, could increase the risk of bacterial or microbial outbreaks.[113]

This existing work is a strong basis for understanding the common elements of health and the health system for GCR.

Knowledge and information

Knowledge and information relates to the processes and techniques by which humans gain, share and store an understanding of the world. This knowledge and information can be an important factor in addressing shared global challenges. It could also be a contributor to risk if dangerous knowledge and capabilities are in the hands of malicious actors or if our information systems are corrupted. Protecting knowledge and information in the face of catastrophe might also be important for rebuilding civilization.

There have been some research efforts at understanding this issue across GCR. Indeed, Vicky Yang and Anders Sandberg recognize this area as "a critical component [that] crosscuts a wide number of risks but remains less explored".[114] These researchers focus on what they refer to as "collective intelligence", which they define as how human groups process distributed information effectively to make collective decisions and action.

In another report, researchers from CSER, the Alan Turing Institute and the UK's defense department claim that "access to reliable information is crucial to the ability of a democratic society to coordinate effective collective action, especially when responding to crises such as global pandemics, and complex challenges such as climate change."[115] They define the challenges surrounding this as "epistemic security", where society averts threats to the processes by which reliable information is produced, distributed, acquired and assessed within the society.

Technology has led to a set of threats and vulnerabilities in our systems of information production and exchange. For example, bad actors could more readily interfere with decision-making processes through disinformation or misinformation. Or the challenges of evaluating and spreading trustworthy information in the face of information abundance could exacerbate polarization and hinder collective action in major challenges.

The way in which knowledge and information cuts across GCR requires a more thorough and detailed investigation, including the policy implications. For example, governments might be involved in managing the information and attention hazards that develop from the production and dissemination of true but dangerous information, such as the genomic sequence of highly virulent pathogens.[116] Where dysfunction of the information ecosystem impacts democratic processes, the threat is to the government itself functioning. The Consilience Project, for example, is focused on this problem.[117] And bad information fed into decision-making processes, particularly in nuclear command and control, could be a risk factor for nuclear war scenarios.

Technology and innovation

Technology and innovation refers to the advancements in capability to better address societal challenges or human needs. It encompasses the research, development, diffusion and adoption of these advancements – which can come in the form of products, processes, tools and methods – through society and the economy.

Technology and innovation is itself a source of GCR. Artificial intelligence, biotechnology, geoengineering and weapons of mass destruction are fundamentally technological capabilities that happen to have globally catastrophic potential. If technology and innovation is about making capabilities more powerful, efficient and accessible, these aspects can be captured for malicious intent or lead to unintended catastrophic consequences. Should a currently unknown global catastrophic threat become known or developed, it is likely to be from a new technologic capability.

But technology and innovation is relevant as a cross-cutting issue not simply because it drives the catastrophic potential of these technologies. Non-GCR technologies change the nature of the threats. For example, health technology, space technology, information and communications systems, cyber capabilities and quantum computing, among others, complicate or shape the threat landscape.

Advances in technology and innovation could also be part of the solutions for GCR. For nuclear weapons, climate change and near-Earth objects, as well as for technology-based threats like AI and biotechnology, technological solutions might be critical for reducing GCR. For example, innovative tools, such as blockchain technology, could help nuclear stability through the verification of nuclear weapons systems.[118] Renewable energy sources and advanced energy storage solutions will be critical to climate change. Healthcare technologies and advances in food production and agriculture could help build resilience to multiple global catastrophe scenarios. And AI can help governments find or implement new solutions to GCR.

One technology-led approach to reducing GCR is called differential technological development. In the key paper on this topic, GCR researchers suggested that, using this approach to responsible innovation, "it may beneficial to delay risk-increasing technologies and preferentially advance risk-reducing defensive, safety, or substitute technologies".[119]

Governments develop policy for technology and innovation without necessarily considering GCR. But these policies could shape how GCR plays out. Technology policy is a priority for many governments, mostly with a focus on its benefit for the economy and security. It shapes research and development funding and approaches, intellectual property rights, consumer protection, data privacy and protection, development of education and the workforce for STEM (science, technology, engineering and mathematics) fields, digital infrastructure such as telecommunications systems, and the ecosystem for entrepreneurs and start-ups.

Each of these elements of technology policy shapes how GCR develops and how it might be reduced. And, in reducing GCR, policymakers will have to grapple with how to allow and oversee technological development and use when new technologies can lead to such grave risk as well as potential societal benefits.

Technology and innovation is somewhat unique as a cutting issue because it also intersects heavily with many of the other cross-cutting domains, particularly security and defense, economy and finance, infrastructure and the built environment, and knowledge and information. Understanding these connections and their relationships with GCR could also be useful.

Society and culture

Society and culture refers to how groups of individuals organize, operate, interact with each other, and develop shared beliefs, values, norms, customs and practices. It encompasses areas related to religion, art, national identity, social hierarchies and institutional structures, from the international to the family level. As a cross-cutting domain for GCR, society and culture can influence how risk is perceived and acted on by individuals and communities. Risk is underpinned and shaped by moral codes of a society. Ultimately, society and culture shapes how policymakers act on GCR. However, as with other cross-cutting domains, these interlinkages require further investigation.

Groups, whether national or sub-national, that have certain societal and cultural features might fare better in a world of increasing GCR. These features, such as trust and cooperation, national identity and social cohesion, are likely to improve resilience in the face of crisis. Societies that have previously dealt with major catastrophes might also have the collective experience and memory, which could position them better for GCR. For example, countries that had severe outbreaks of disease of pandemic potential initially performed better with COVID-19. And countries that dealt with existential security threats to their national survival during the 20th century might be better able to conceive of, and form whole-of-nation preparedness for, GCR.

Global catastrophic risk could also shape how societies and culture develop. It might result in the clash of different societies and cultures – climate change and sun-blocking scenarios could result in mass movement of people. It could also result in shifts in cultural mindset. It could shape social cohesion, national identity, trust in institutions and broader political dynamics. For example, in one study, individual citizen's values shift between liberal and authoritarian when faced with sudden exposure to global catastrophe or massive national crisis.[120] Ultimately, societies and cultures could radically transform after a catastrophe.

Recommendations

All-hazards GCR policy requires further investigation and development. The field of GCR studies should increase their efforts to understand all-hazards GCR, while policy advocates and policymakers should develop all-hazard GCR policies. Both frameworks above – overarching and cross-cutting – represent starting points for researchers, advocates and policymakers. The following set of recommendations are targeted at the major gaps in all-hazards GCR policy.

- Researchers should test the overarching and cross-cutting frameworks in this report against their existing work to identify gaps in the frameworks and opportunities for further development. The frameworks are intended to represent a set of mutually exclusive and collectively exhaustive issues, but they are likely to require refinement.

- Researchers should identify, study and develop policy options for the important risk drivers and factors. A small, dedicated research project – one that engages with a multidisciplinary range of experts and policymakers, and uses analytical techniques like complexity theory and root cause analysis – could quickly advance this work. Understanding these drivers and factors would allow policymakers to direct their efforts to the underlying causes of GCR and those related issues that are exacerbating the risk.

- Building on the resilience literature in GCR studies, policy researchers and policymakers could identify each of the critical national systems requiring resilience, and map how various GCR scenarios impact these systems to identify key points of failure or vulnerability. This work would benefit by drawing in experts from government and critical infrastructure providers.

- Further research is needed to investigate and develop all-hazard GCR policy options. A research project in a policy-focused research organization or think tank could develop insights from the "GCR policy database" (a collection of policy ideas from the field).[121] This work could include finding gaps where policy ideas have not been developed, developing a policy research agenda and expanding the set of possible policy responses.

Although further research is needed, institutional challenges are blocking further work in this area. For example, research institutes are not focused on overarching and cross-cutting issues potentially because they structure their research along threat and hazard lines, recruit domain experts from within those fields, struggle to incorporate lessons from other fields and disciplines, and receive funding for threat-specific research, such as AI and biological risk. The following set of recommendations could better address these blockers:

- Research organizations in the GCR studies field should recruit from other disciplines and appoint specific positions relating to elements of overarching or cross-cutting policy. For new research projects, these organizations should consider finding and collaborating with experts from other fields, particularly on cross-cutting domains, such as IR, economics, political science and infrastructure. They should better engage with the field of risk analysis, including operational, project and financial risk.

- Philanthropic organizations should more highly prioritize and fund projects focused on all-hazards GCR. For example, funders could allocate staff to analyze all-hazards related projects, just as they might on AI or biological risks, or develop different approaches to analyzing projects focused on all-hazards GCR. Recognizing the uncertainty in threat-specific risk assessments, these organizations could allocate some funding towards all-hazards GCR projects regardless of their relationship to or impact on specific threats.

- The field also needs to promote the value of all-hazards GCR approaches and share insights and success stories. For example, the field could invite risk management experts from across the private and public sectors to conferences, events and workshops in order to gain an understanding of different frameworks and approaches to all-hazards risk management. Organizational leaders should catalyze the move away from the threat and hazard lens to a more systemic approach.

- Policy advocates and policymakers focused on GCR should demand more all-hazards GCR research and policy analysis from experts. They could co-create policy recommendations with experts across each of the areas in the overarching and cross-cutting frameworks.

Appendix: Identifying the global catastrophic threats and hazards

An all-hazards approach to GCR benefits from knowing what the specific threats and hazards are. The exact list can depend on one's definition of GCR and one's interpretation of how risky a certain type of threat may be. This report does not seek to resolve these matters, but instead compiles prior lists of global catastrophic threats as contained in significant publications that survey the space of GCR.

The following list contains, as far as the author is aware, all the traditionally published books where the entirety or majority of the text is focused on GCR (and not on only one individual threat or hazard):

- Asimov, Isaac. *A choice of catastrophes: The disasters that threaten our world*. Simon & Schuster (1979).
- Leslie, John. *The End of the World: the science and ethics of human extinction*. Psychology Press (1998).
- Rees, Martin J. *Our final century: Will the human race survive the twenty-first century?*. BasicBooks (2003).
- Posner, Richard A. *Catastrophe: risk and response*. Oxford University Press (2004)
- Martin, James. *The Meaning of the 21st Century: A Vital Blueprint for Ensuring Our Future*." (2006).
- Smil, Vaclav. *Global catastrophes and trends: The next 50 years*. MIT Press (2008)
- Bostrom, Nick, and Milan M. Cirkovic (Eds). *Global catastrophic risks*. Oxford (2008)
- Wells, Willard. *Apocalypse When? Calculating How Long the Human Race Will Survive*. Springer (2009)
- Wuthnow, Robert. *Be Very Afraid: The Cultural Response to Terror, Pandemics, Environmental Devastation, Nuclear Annihilation, and Other Threats*. Oxford University Press (2010).
- Jha, Alok. *50 Ways the World Could End: The Doomsday Handbook*. Quercus Publishing (2011).
- Lisboa, Maria Manuel. *The End of the World: Apocalypse and Its Aftermath in Western Culture*. Open Book Publishers (2011).
- Darling, David, and Dirk Schulze-Makuch. *Megacatastrophes! Nine Strange Ways the World Could End*. OneWorld Publications (2012)
- Guterl, Fred. *The Fate of the Species: Why the Human Race May Cause Its Own Extinction and How We Can Stop It.* Bloomsbury Press (2012).
- Dartnell, Lewis. *The Knowledge: How to Rebuild Civilization in the Aftermath of a Cataclysm*. Random House (2014).
- Torres, Phil. *The End: What Science and Religion Tell Us about the Apocalypse*. Pitchstone Publishing (2016)
- Haggstrom, Olle. *Here Be Dragons: Science, Technology and the Future of Humanity*. Oxford University Press (2016)

- Cribb, Julian. *Surviving the 21st Century: Humanity's Ten Great Challenges and How We Can Overcome Them*. Springer (2016)
- Torres, Phil. *Morality, Foresight, and Human Flourishing: An Introduction to Existential Risks*. Pitchstone Publishing (2017).
- Clarke, Richard, and R.P. Eddy. *Warnings: Finding Cassandras to Stop Catastrophes*. HarperCollins (2017).
- Rees, Martin. *On the Future: Prospects for Humanity*. Princeton University Press (2018).
- Walsh, Bryan. *End Times: A Brief Guide to the End of the World*. Hachette Books (2019).
- Mckibben, Bill. *Falter: Has the Human Game Begun to Play Itself Out?* Henry Holt and Co. (2020)
- Letwin, Oliver. *Apocalypse How? Technology and the Threat of Disaster*. Atlantic Books (2020).
- Ord, Toby. *The Precipice: Existential Risk and the Future of Humanity*. Bloomsbury Publishing (2020).
- Brain, Marshall. *The Doomsday Book: The Science Behind Humanity's Greatest Threats*. Sterling Publishing Company (2020).
- Moynihan, Thomas. *X-Risk: How Humanity Discovered Its Own Extinction*. MIT Press (2021).
- Leigh, Andrew. *What's the Worst That Could Happen? Existential Risk and Extreme Politics*. MIT Press (2021).
- Bess, Michael. *Planet in Peril: Humanity's Four Greatest Challenges and How We Can Overcome Them*. Cambridge University Press (2022).
- Torres, Émile. *Human Extinction: A History of the Science and Ethics of Annihilation*. Taylor and Francis (2022).
- Cribb, Julian. *How to Fix a Broken Planet: Advice for Surviving the 21st Century*. Cambridge University Press (2023).
- Taylor, Noah B. *Existential Risks in Peace and Conflict Studies*. Springer Nature (2023)

The publications listed above do not include every work that surveys GCR. For example, it excludes edited journal volumes and may exclude surveys published in languages other than English. Nonetheless, it constitutes a significant body of prior surveys of GCR, and therefore makes for a reasonable data set for identifying the global catastrophic threats and hazards. Many of these texts devote individual chapters to specific threats and hazards, making it a relatively simple exercise to identify the full set.

Another source for identifying this of threats and hazards are the reports by the Global Challenges Foundation dedicated to GCR, which have been released annually since 2015 (excluding 2019). This list represents the specific threats and hazards which received attention across the 7 reports, along with the number of mentions:[122]

- Nuclear warfare (7 mentions)
- Biological and chemical warfare (6 mentions)
- Pandemics (7 mentions)
- Artificial intelligence (7 mentions)

- Near-Earth asteroids (7 mentions)
- Supervolcanic eruption (7 mentions)
- Climate catastrophe (6 mentions)
- Ecological collapse (6 mentions)
- Unknown risks (4 mentions)
- Solar geoengineering (3 mentions)
- Engineered pandemic or synthetic biology (2 mentions)
- Global population size (1 mention)
- Climate tipping points (1 mention)
- Black hole (1 mention)
- Nanotechnology (1 mention)
- Quantum Computing (1 mention)

Based on these texts, a set of threats and hazards appear consistently. This set can be considered as some level of consensus about the most plausible sources of GCR. How threats and hazards are articulated differs between texts, so this list has consolidated synonymous terms that refer to the same concept into the following umbrella threats and hazards.

- Nuclear weapons
- Climate change
- Pandemics
- Biotechnology
- Artificial Intelligence (AI)
- Near-Earth objects, such as asteroids and comets
- Supervolcanic eruption
- Ecological collapse

The books and reports also identify other threats and hazards but on much less frequent or consistent basis. This is probably due to different definitions of risk as well as more speculative ideas of what could lead to a global catastrophe. This list represents those threats and hazards that have a weaker level of consensus:

- Solar geoengineering
- Nanotechnology
- Quantum computing
- Societal collapse
- Global totalitarian regime
- Cyber
- Physics experiments
- Geomagnetic storms
- Extraterrestrial intelligence
- Stellar explosion
- Global population size

These lists should not be taken as correct, definitive, complete, agreed or ranked. Indeed, some items in this list – such as global population size – do not necessarily qualify as a threat or

hazard, but perhaps as a risk factor or driver. And “unknown” risk, which some texts do identify, may require its own classification given that the source of the risk is completely unknown.

Furthermore, other threats and hazards might have been missed. The entire field of GCR studies may be biased towards systematically focusing on certain threats and ignore others. For example, one study claims that the field focuses mainly on threats of fast-moving catastrophes and neglects slower processes.[123] Another problem might be circular reasoning, where authors defer to earlier assessments of GCR rather than testing or refining the list of threats and hazards. Some texts after 2020, for example, rely heavily on the risk assessment and ranking provided by *The Precipice*. A report for the UN Office for Disaster Risk Reduction by the Simon Institute for Longterm Governance, International Science Council and the Centre for the Study of Existential Risk identified a number of hazards with potential for globally catastrophic escalation that do not commonly appear, including antimicrobial resistance, harmful algal bloom, infrastructure disruption and the internet of things.[124]

For this very reason, all-hazard approaches to GCR research and policy can be powerful. They are somewhat agnostic to the list of threats and hazards. So they provide a mechanism to deal with ignored, deprioritized or unknown threats, as well as pathways and scenarios within an individual threat that are ignored, deprioritized or unknown. The list of threats and hazards, and the perceived consensus around them, might obfuscate the gaps in our understanding when it comes to reducing GCR.

[1] This report distinguishes between the terms risk, threat and hazard. A hazard is a phenomenon arising from a natural or anthropogenic source that, without a malicious intent, could cause harm. For example, a flood or an industrial accident are hazards. A threat is phenomenon arising from an anthropogenic source with a deliberate intent to cause harm. For example, a terrorist attack or military conflict is a threat. Risk is the potential of harm that arises as a function of threat or hazard meeting a vulnerability. For example, the risk of a terrorist attack would be the probability that a certain level of human, economic and societal harm is caused. In contrast to more common usage of the term, risk is not synonymous with threat or hazard. A useful lexicon is that of the United Nation Office for Disaster Risks Reduction. "2009 UNISDR terminology on disaster risk reduction" (2009) https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction. It defines "risk" as "The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity". It defines hazard as "A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation." (It provides no definition for threat given its focus on disasters.)

[2] Baum, Seth, and Anthony Barrett. "Global catastrophes: The most extreme risks." Risk in extreme environments: Preparing, avoiding, mitigating, and managing. New York: Routledge (2017): 174-184; Cirkovic, Nick Bostrom Milan M. Global catastrophic risks. Oxford, 2008; Baum, Seth, and Anthony Barrett. "Towards an integrated assessment of global catastrophic risk." In Catastrophic and Existential Risk: Proceedings of the First Colloquium, Garrick Institute for the Risk Sciences, University of California, Los Angeles, pp. 41-62. 2018.

[3] Turchin, Alexey, and David Denkenberger. "Global catastrophic and existential risks communication scale." Futures 102 (2018): 27-38.

[4] Baum, Seth, and Anthony Barrett. "Towards an integrated assessment of global catastrophic risk." In *Catastrophic and Existential Risk: Proceedings of the First Colloquium, Garrick Institute for the Risk Sciences, University of California, Los Angeles*, pp. 41-62. (2018).

[5] Kemp, Luke, Chi Xu, Joanna Depledge, Kristie L. Ebi, Goodwin Gibbins, Timothy A. Kohler, Johan Rockström et al. "Climate Endgame: Exploring catastrophic climate change scenarios." Proceedings of the National Academy of Sciences 119, no. 34 (2022): e2108146119.

[6] Hin-Yan Liu, Kristian Cedervall Lauta, and Matthijs Michiel Maas, "Governing Boring Apocalypses: A new typology of existential vulnerabilities and exposures for existential risk research," Futures 102 (September 2018): 6-19.

[7] Shahar Avin, Bonnie C. Wintle, Julius Weitzdörfer, Seán S. Ó hÉigeartaigh, William J. Sutherland, and Martin J. Rees, "Classifying global catastrophic risks," Futures 102 (September 2018): 20-26.

[8] Owen Cotton-Barratt, Max Daniel, and Anders Sandberg, "Defence in Depth Against Human Extinction: Prevention, Response, Resilience, and Why They All Matter," Global Policy 11, no. 3 (January 24, 2020), https://doi.org/10.1111/1758-5899.12786.

[9] Adini, Bruria, Avishay Goldberg, Robert Cohen, Daniel Laor, and Yaron Bar-Dayan. "Evidence-based support for the all-hazards approach to emergency preparedness." Israel journal of health policy research 1, no. 1 (2012): 1-7; Ayyub, Bilal M., William L. McGill, and Mark Kaminskiy. "Critical asset and portfolio risk analysis: An all-hazards framework." Risk Analysis: An International Journal 27, no. 4 (2007): 789-801; Penta, Samantha, James Kendra, Valerie Marlowe, and Kimberly Gill. "A disaster by any other name?: COVID-19 and support for an All-Hazards approach." Risk, Hazards & Crisis in Public Policy 12, no. 3 (2021): 240-265; Deville, Joe, and Michael Guggenheim. "From preparedness to risk: from the singular risk of nuclear war to the plurality of all hazards." The British Journal of Sociology 69, no. 3 (2018): 799-824.

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[11] Public Safety Canada. "All-Hazards Risk Assessment". Accessed September 6, 2023, from https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/mrgnc-prprdnss/ll-hzrds-rsk-ssssmnt-en.aspx

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[17] This framework is based on a combination and distillation of these other operational and disaster risk management frameworks. The categories in the overarching GCR policy framework appear across various other frameworks. These terms also appear across a range of academic articles on GCR. For example, one academic drew three lessons from COVID-19 for other GCR: prevention and preparation; global coordination; and rapid response. Salami, R. K. (2022). "A letter in the Lancet of June 2020 claimed the COVID-19 pandemic teaches lessons we must embrace to overcome two additional existential threats: nuclear war and global warming. What lessons can we learn from the global response to COVID-19 that could help the world address future threats such as climate change or the proliferation of nuclear weapons? Muller and Nathan." Medicine, Conflict and Survival, 38(4), 332-338.

[18] The UNDRR defines disaster risk governance as "The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy." United Nation Office for Disaster Risks Reduction. "2009 UNISDR terminology on disaster risk reduction" (2009) https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction. The Department of Homeland Security defines risk governance as "Actors, rules, practices, processes, and mechanisms concerned with how risk is analyzed, managed, and communicated." Department of Homeland Security. "DHS Risk Lexicon: 2010 edition". Risk Steering Committee. Accessed 6 September, 2023, from https://www.cisa.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf

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[21] Hilton, Samuel and Caroline Baylon. "Risk management in the UK: What can we learn from COVID-19 and are we prepared for the next disaster?" All-Party Parliamentary Group for Future Generations. Available at https://www.cser.ac.uk/media/uploads/files/Risk_Management_in_the_UK_Final1.pdf ; Ord, Toby, Angus Mercer, and Sophie Dannreuther. 'Future Proof: The Opportunity to Transform the UK's Resilience to Extreme Risks' (June 2021) Available at https://drive.google.com/file/d/1LHn3nzxF2p68SfhwiPLCb5FMaMLq1dk6/view; See also Hodgkin, Rosa, and Tom Sasse. "Managing extreme risks: how the new government can learn from Covid to be better prepared for the next crisis." (2022).

[22] House of Lord Select Committee on Risk Assessment and Risk Planning. "Preparing for Extreme Risks: Building a Resilient Society." HL Paper 110 Report of Session 2021–22 (2021). In its report, the Committee stated that "Many of our witnesses called for the establishment of a body within Government which could provide independent challenge to the risk assessment process and place pressure on the Government to undertake the necessary actions to either mitigate or prevent disruptive events."

[23] Boyd, Matt, and Nick Wilson. "Anticipatory governance for preventing and mitigating catastrophic and existential risks." Policy Quarterly 17, no. 4 (2021): 20-31.

[24] Kemp, Luke, and C. Rhodes. "The cartography of global catastrophic governance." Global Challenges Foundation (2020); See also Vöneky, Silja. "Human rights and legitimate governance of existential and global catastrophic risks." Human Rights, Democracy, and Legitimacy in a World of Disorder, CUP (2018): 139-162.

[25] Risk understanding is a combination of risk assessment, analysis, monitoring and warning. The UNDRR defines "Disaster risk assessment" as a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend." United Nation Office for Disaster Risks Reduction. "2009 UNISDR terminology on disaster risk reduction" (2009) Available at https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction. The Department of Homeland Security defines risk assessment as "product or process which collects information and assigns values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making" and defines risk identification as "a process of finding, recognizing, and describing potential risks." Department of Homeland Security. "DHS Risk Lexicon: 2010 edition". Risk Steering Committee. Accessed 6 September, 2023, from https://www.cisa.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf

[26] Baum, Seth D. "The challenge of analyzing global catastrophic risks." Decision Analysis Today, vol. 38, no. 1 (July), pages 20-24 (2019); Beard, Simon, Thomas Rowe, and James Fox. "An analysis and evaluation of methods currently used to quantify the likelihood of existential hazards." Futures 115 (2020): 102469.

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[31] Rios Rojas, Clarissa, Catherine Rhodes, Shahar Avin, Luke Kemp, and S. J. Beard. "Foresight for unknown, long-term and emerging risks, Approaches and Recommendations." (2021); Cotton-Barratt, Owen, Max Daniel, and Anders Sandberg. "Defence in depth against human extinction: Prevention, response, resilience, and why they all matter." Global Policy 11, no. 3 (2020): 271-282.; Karger, Ezra, Pavel D. Atanasov, and Philip Tetlock. "Improving judgments of existential risk: Better forecasts, questions, explanations, policies." January 17, 2022. Available at http://dx.doi.org/10.2139/ssrn.4001628.
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[33] Seger, Elizabeth, Shahar Avin, Gavin Pearson, Mark Briers, Seán Ó. Heigeartaigh, Helena Bacon, Henry Ajder et al. "Tackling threats to informed decision-making in democratic societies: Promoting epistemic security in a technologically-advanced world." (2020). Available at https://www.cser.ac.uk/resources/epistemic-security/
[34] The UNDRR defines risk prevention as "Activities and measures to avoid existing and new disaster risks". The term risk mitigation is sometimes used interchangeably with risk prevent. United Nation Office for Disaster Risks Reduction. "2009 UNISDR terminology on disaster risk reduction" (2009) Available at https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction
[35] The definition here is based on World Health Organization. "Health topics: Risk factors" https://web.archive.org/web/20191017230850/who.int/topics/risk_factors/en/. For a more thorough and specific definition, see: "Risk factor: an environmental, behavioral, or biologic factor confirmed by temporal sequence, usually in longitudinal studies, which if present directly increases the probability of a disease occurring, and if absent or removed reduces the probability. Risk factors are part of the causal chain, or expose the host to the causal chain. Once disease occurs, removal of a risk factor may not result in a cure." Beck, James D. "Risk revisited." *Community dentistry and oral epidemiology* 26, no. 4 (1998): 220-225.
[36] Risk driver is sometimes used interchangeably with risk factor. See: "Risk factor." Open Risk Manual. Accessed 17 October, 2023 from https://www.openriskmanual.org/wiki/Risk_Factor. For the purposes of this report, risk driver and risk factor are separate. In practice, some risk drivers and factors might be the same, or it may be difficult to distinguish between what causes a risk and what exacerbates it.
[37] Smith, Preston G., and Guy M. Merritt. *Proactive risk management: Controlling uncertainty in product development*. CRC Press (2020) defines a risk driver as "Something existing in the project environment that leads one to believe that a particular risk would occur."
[38] Without further identification and assessment of risk factors and drivers for GCR, it is difficult to provide examples here. An indicative example could be, the risk driver that led to the sinking of the Titanic was the poor quality construction of the hull, while the risk factors included navigating through icy water, high speeds and inadequate lifeboat requirements.
[39] Ord, Toby. *The Precipice: Existential Risk and the Future of Humanity*. Bloomsbury Publishing (2020).
[40] Cotton-Barratt, Owen, Max Daniel, and Anders Sandberg. "Defence in depth against human extinction: Prevention, response, resilience, and why they all matter." Global Policy 11, no. 3 (2020): 271-282
[41] The UNDRR defines risk preparedness as "The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters." The term risk mitigation sometimes also refers to actions that would be considered risk preparedness. For example, the UNDRR defines risk mitigation as "the lessening or minimizing of the adverse impacts of a hazardous event." United Nation Office for Disaster Risks Reduction. "2009 UNISDR terminology on disaster risk reduction" (2009) Available at https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction. And the US Department of Homeland Security defines risk mitigation as the "Application of measure or measures to reduce the likelihood of an unwanted occurrence and/or its consequences". Department of Homeland Security. "DHS Risk Lexicon: 2010 edition". Risk Steering Committee. Accessed 6 September, 2023, from https://www.cisa.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf
[42] The UNDRR defines vulnerability as "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards". The Department of Homeland Security defines it as "physical feature or operational attribute that renders an entity, asset, system, network, or geographic area open to exploitation or susceptible to a given hazard".
[43] Liu, Hin-Yan, Kristian Cedervall Lauta, and Matthijs Michiel Maas. "Governing Boring Apocalypses: A new typology of existential vulnerabilities and exposures for existential risk research." Futures 102 (2018): 6-19.
[44] Baum, Seth D. "Resilience to Global Catastrophe." In Trump, Benjamin D., Marie-Valentine Florin, and I. Linkov. *IRGC Resource Guide on Resilience (Volume 2)*. International Risk Governance Center (IRGC) (2018).
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_Reconfiguring_Resilience_for_Existential_Risk_Sub.pdf
[46] Green, Brian Patrick. "Emerging technologies, catastrophic risks, and ethics: three strategies for reducing risk." In 2016 IEEE International Symposium on Ethics in Engineering, Science and Technology (ETHICS), pp. 1-7. IEEE, 2016.
[47] Baum, Seth D., David C. Denkenberger, and Jacob Haqq-Misra. "Isolated refuges for surviving global catastrophes." Futures 72 (2015): 45-56; Turchin, Alexey, and Brian Patrick Green. "Aquatic refuges for surviving a global catastrophe." Futures 89 (2017): 26-37; Turchin, Alexey, and Brian Patrick Green. "Islands as refuges for surviving global catastrophes." foresight 21, no. 1 (2019): 100-117; Boyd, Matt, and Nick Wilson. "The prioritization of island nations as refuges from extreme pandemics." Risk Analysis 40, no. 2 (2020): 227-239.
[48] ALLFED. “ALLFED Publications.” Accessed on September 6, 2023. https://allfed.info/research/publications-and-reports.
[49] Tzachor, Asaf, Catherine E. Richards, and Lauren Holt. "Future foods for risk-resilient diets." Nature Food 2, no. 5 (2021): 326-329.
[50] Hilton, Samue and Sahil Shah. “Why are food shortages not listed as a risk in the National Risk Register?” 2021. Available at https://www.cser.ac.uk/resources/food-shortages-NRR.
[51] The UNDRR defines risk response as “Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.” It also has as separate definition for risk recovery: “The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and “build back better”, to avoid or reduce future disaster risk.” United Nation Office for Disaster Risks Reduction. “2009 UNISDR terminology on disaster risk reduction” (2009) Available at https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction.
[52] Dartnell, Lewis. The Knowledge: How to Rebuild Civilization in the Aftermath of a Cataclysm. Penguin, 2015.
[53] Belfield, Haydn. "Collapse, Recovery, and Existential Risk." How Worlds Collapse: What History, Systems, and Complexity Can Teach Us About Our Modern World and Fragile Future (2023): 61.
[54] The US Department of Homeland Security defines risk communication as the “exchange of information with the goal of improving risk understanding, affecting risk perception, and/or equipping people or groups to act appropriately in response to an identified risk.” Department of Homeland Security. “DHS Risk Lexicon: 2010 edition”. Risk Steering Committee. Accessed 6 September, 2023, from https://www.cisa.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf. The World Health Organization defines risk communication as “the real-time exchange of information, advice and opinions between experts or officials and people who face a hazard or threat to their survival, health, or economic or social wellbeing.” World Health Organization. “Risk communication and community engagement (RCCE).” World Health Organization. Accessed 6 September, 2023 from https://www.who.int/emergencies/risk-communications.
[55] Rode, David C., and Paul S. Fischbeck. "Apocalypse now? Communicating extreme forecasts." International Journal of Global Warming 23, no. 2 (2021): 191-211.
[56] Fischhoff, Baruch. "Communication Unplugged: Twenty Years of Process." Risk Analysis 15, no. 2 (1995): 137-145.
[57] Budescu, David V., Han-Hui Por, Stephen B. Broomell, and Michael Smithson. "The interpretation of IPCC probabilistic statements around the world." Nature Climate Change 4, no. 6 (2014): 508-512.
[58] Winton Centre for Risk and Evidence Communication. “Resources - Resources for civil servants and government officials.” University of Cambridge Winton Centre for Risk and Evidence Communication.
[59] The author could not find one academic article or report focused on this topic. The closest example was Turchin and Denkenberger (2018), though this was focused on a risk matrix as a communication tool, rather than the mechanisms and considerations of communicating about global catastrophic risk with the public.
[60] Petridou, Evangelia, Erna Danielsson, Anna Olofsson, Minna Lundgren, and Christine Große. "If crisis or war comes: A study of risk communication of eight European Union member states." Journal of International Crisis and Risk Communication Research 2, no. 2 (2019): 207-232.
[61] Boyd, Matt, and Nick Wilson. "Existential risks to humanity should concern international policymakers and more could be done in considering Them at the International Governance Level." Risk Analysis 40, no. 11 (2020): 2303-2312; Farquhar, Sebastian, John Halstead, Owen Cotton-Barratt, Stefan Schubert, Haydn Belfield, and Andrew Snyder-Beattie. "Existential risk: Diplomacy and governance." Global priorities project 2017 (2017); Cotton-Barratt, Owen, Max Daniel, and Anders Sandberg. "Defence in depth against human extinction: Prevention, response, resilience, and why they all matter." Global Policy 11, no. 3 (2020): 271-282.
[62] Ord, Mercer and Sophie Dannreuther (2021).
[63] Erskine, Toni. "Existential threats, shared responsibility, and Australia’s role in ‘coalitions of the obligated’." Australian Journal of International Affairs 76, no. 2 (2022): 130-137.
[64] Cross-cutting policies are a particularly challenging policy issue for governments because they often do fit neatly into the somewhat artificial boundaries created by legislative regimes and bureaucratic structures. Cross-cutting issues might lack a clear public constituency, which gets reflected in a lack of ownership in the policy establishment. Such policy issues might have no strategic policy guidance, either through legislation or from executive action. As a result, cross-cutting issues can go fought over or poorly addressed between different departments. And funding arrangements can become uncoordinated

and potentially conflicting. Christensen, Johan, and Kathia Serrano Velarde. "The role of advisory bodies in the emergence of cross-cutting policy issues: comparing innovation policy in Norway and Germany." In Experts and Democratic Legitimacy, pp. 49-65. Routledge, 2020; Landry, Joe, James Floch, Marissa Fortune, and Emma Richardson. "Preparing for the United Nations Security Council: Canadian approaches to policy development." International Journal 77, no. 3 (2022): 503-514.

[65] See discussion on food resilience earlier in the report. See also Baum, Seth D., David C. Denkenberger, Joshua M. Pearce, Alan Robock, and Richelle Winkler. "Resilience to global food supply catastrophes." *Environment Systems and Decisions* 35 (2015): 301-313; Tzachor, Asaf, Catherine E. Richards, and Lauren Holt. "Future foods for risk-resilient diets." *Nature Food* 2, no. 5 (2021): 326-329; Winstead, Daniel Jefferson, and Michael Gregory Jacobson. "Food resilience in a dark catastrophe: A new way of looking at tropical wild edible plants." *Ambio* 51, no. 9 (2022): 1949-1962.

[66] There are only two clear examples of the term being used as directly relating to global catastrophic risk policy. Boyd and Wilson state that "a final challenge to governance of extreme risks is that for many cross-cutting threats there is no individual or organization that has accountability for oversight of the risk." Boyd, Matt, and Nick Wilson. "Anticipatory governance for preventing and mitigating catastrophic and existential risks." Policy Quarterly 17, no. 4 (2021): 20-31. And in their submission to the House of Lords Select Committee on Risk Assessment and Risk Planning, CSER researchers state that "direct, often technological, solutions to specific hazards may address part of the threat, but do surprisingly little to reduce risk if underlying cross-domain vulnerabilities are not addressed." Avin, Shahar, Lalitha Sundaram, Jess Whittlestone, Matthijs M. Maas, and Tom Hobson. "Centre for the Study of Existential Risk – Written evidence (RSK0063)." Centre for the Study of Existential Risk. Available at https://committees.parliament.uk/writtenevidence/21939/pdf (2021). In this context, they identify "reaching informed collective action during times of crisis" as a "cross-cutting vulnerability".

[67] Avin, Shahar, Bonnie C. Wintle, Julius Weitzdörfer, Seán S. Ó hÉigeartaigh, William J. Sutherland, and Martin J. Rees, "Classifying global catastrophic risks," Futures 102 (September 2018): 20-26.

[68] Lawrence, Michael, Thomas Homer-Dixon, Scott Janzwood, Johan Rockstrom, Ortwin Renn, and Jonathan F. Donges. "Global Polycrisis: The causal mechanisms of crisis entanglement." Available at SSRN 4483556 (2023).

[69] This taxonomy was developed based on a combination of these publication, the taxonomy of critical infrastructure systems that governments use to determine those assets and systems that are nationally significant, and a high-level analysis of the risk drivers and factors for multiple global catastrophic threats and hazards.

[70] Sears, Nathan Alexander. "Existential security: Towards a security framework for the survival of humanity." Global Policy 11, no. 2 (2020): 255-266; Sears, Nathan Alexander. "International politics in the age of existential threats." Journal of Global Security Studies 6, no. 3 (2021): ogaa027; Sears, Nathan Alexander. "Great Powers, Polarity, and Existential Threats to Humanity: An Analysis of the Distribution of the Forces of Total Destruction in International Security." (2021); Sears, Nathan Alexander. "Great Power Rivalry and Macrosecuritization Failure: Why States Fail to "Securitize" Existential Threats to Humanity." PhD diss., University of Toronto (Canada), 2023.

[71] Stephen Clare. "Great Power Conflict" Founders Pledge Accessible at https://www.founderspledge.com/research/great-power-conflict (2021).

[72] Kemp, Luke, and C. Rhodes. "The cartography of global catastrophic governance." Global Challenges Foundation (2020).

[73] Halstead, John. "Stratospheric aerosol injection research and existential risk." Futures 102 (2018): 63-77; Hamilton, Chase. "Space and Existential Risk: The Need for Global Coordination and Caution in Space Development." Duke L. & Tech. Rev. 21 (2022): 1; Kemp, Luke, Chi Xu, Joanna Depledge, Kristie L. Ebi, Goodwin Gibbins, Timothy A. Kohler, Johan Rockström et al. "Climate Endgame: Exploring catastrophic climate change scenarios." Proceedings of the National Academy of Sciences 119, no. 34 (2022): e2108146119; Maas, Matthijs M., Kayla Matteucci, and Di Cooke. "Military Artificial Intelligence as Contributor to Global Catastrophic Risk." The Era of Global Risk (2023).(eds. SJ Beard, Martin Rees, Catherine Richards & Clarissa Rios-Rojas). Open Book Publishers (2022); Seth D. Baum, 2017. "A Survey of Artificial General Intelligence Projects for Ethics, Risk, and Policy." Global Catastrophic Risk Institute Working Paper 17-1.

[74] Note that governance as a cross-cutting policy differs from risk governance as an overarching policy. The former is how governance arrangements impact risk; the latter is how GCR itself is governed.

[75] These biases are not exclusive to policy-makers in democracies.

[76] John, Tyler, and William MacAskill. "Longtermist institutional reform." *The Long View: Essays on Policy, Philanthropy, and the Long-term Future, Legal Priorities Project Working Paper Series 4-2021* (2021); Araújo, Renan, and Leonie Koessler. "The rise of the constitutional protection of future generations." *Legal Priorities Project Working Paper Series 7-2021* (2021); Martínez, Eric, and Christoph Winter. "Protecting future generations: A global survey of legal academics." *Legal Priorities Project Working Paper Series 1-2021* (2021).

[77] Leigh, Andrew. *What's the Worst That Could Happen? Existential Risk and Extreme Politics*. MIT Press (2021).

[78] Tonn, Bruce. "A design for future-oriented government." *Futures* 28, no. 5 (1996): 413-431; von Knebel, Moritz. "Cross-country comparative analysis and case study of institutions for future generations." Futures 151 (2023): 103181; Stauffer, Maxime, Konrad Seifert, Nora Ammann, and Jan Pieter Snoeij. "Policymaking for the Long-term Future: Improving

Institutional Fit."; Cargill, Natalie, and Tyler M. John. "The Long View: Essays on Policy, Philanthropy, and the Long-term Future." (2021); Jones, Natalie, Mark O'Brien, and Thomas Ryan. "Representation of future generations in United Kingdom policy-making." *Futures* 102 (2018): 153-163

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[81] G. Allen and T. Chan. Artificial Intelligence and National Security. (Belfer Center for International Affairs, Harvard Kennedy School, July 2017); Scouras, James. "Nuclear war as a global catastrophic risk." Journal of benefit-cost analysis 10, no. 2 (2019): 274-295; Military Artificial Intelligence as Contributor to Global Catastrophic Risk.

[82] Sears, Nathan Alexander. "Existential security: Towards a security framework for the survival of humanity." Global Policy 11, no. 2 (2020): 255-266.

[83] Torres, Phil. "Who would destroy the world? Omnicidal agents and related phenomena." Aggression and Violent Behavior 39 (2018): 129-138.

[84] Sundaram, Lalitha, Matthijs M. Maas, and S. J. Beard. "Seven Questions for Existential Risk Studies." Forthcoming in Managing Extreme Technological Risk (ed. Catherine Rhodes) (2022).

[85] Noy, Ilan, and Tomáš Uher. "Four New Horsemen of an Apocalypse? Solar Flares, Super-volcanoes, Pandemics, and Artificial Intelligence." Economics of Disasters and Climate Change 6, no. 2 (2022): 393-416.

[86] Aschenbrenner, Leopold. "Existential risk and growth." Global Priorities Institute. https://globalprioritiesinstitute. org/leopold-aschenbrenner-existential-risk-and-growth (2020); Aschenbrenner, Leopold. "Existential risk and growth." Global Priorities Institute. https://globalprioritiesinstitute. org/leopold-aschenbrenner-existential-risk-and-growth (2020); Trammell, Philip. "Existential Risk and Exogenous Growth." Accessible at https://philiptrammell.com/static/ExistentialRiskAndExogenousGrowth.pdf (2020); Schmidt, Andreas T., and Daan Juijn. "Economic inequality and the long-term future." Politics, Philosophy & Economics (2023): 1470594X231178502.

[87] Weitzman, Martin L. "Fat-tailed uncertainty in the economics of catastrophic climate change." Review of Environmental Economics and Policy (2011). Also see: Stern, Nicholas, Joseph Stiglitz, and Charlotte Taylor. "The economics of immense risk, urgent action and radical change: towards new approaches to the economics of climate change." Journal of Economic Methodology 29, no. 3 (2022): 181-216.

[88] Cropper, "Regulating activities with catastrophic environmental effects"; Pindyck and Wang, "The economic and policy consequences of catastrophes"; Arrow and Priebsch, "Bliss, Catastrophe, and Rational Policy"; Barro and Jin, "On the size distribution of macroeconomic disasters".

[89] Baum, Seth, and Anthony Barrett. "Towards an integrated assessment of global catastrophic risk." In Catastrophic and Existential Risk: Proceedings of the First Colloquium, Garrick Institute for the Risk Sciences, University of California, Los Angeles, pp. 41-62. 2018.

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[91] ALLFED. "ALLFED Publications." Accessed 6 September, 2023 from https://allfed.info/research/publications-and-reports.

[92] Winstead, Daniel Jefferson, and Michael Gregory Jacobson. "Forest Resource Availability After Nuclear War or Other Sun-Blocking Catastrophes." Earth's Future 10, no. 7 (2022): e2021EF002509.

[93] Harrington, Cameron. "The eternal return: Imagining security futures at the Doomsday Vault." Environment and Planning E: Nature and Space (2022): 25148486221145365.

[94] Tzachor, Asaf. "A System Dynamics Perspective of Food Systems, Environmental Change and Global Catastrophic Risks." Environmental Change and Global Catastrophic Risks (January 5, 2022) (2022).

[95] Asokan, Asha, and Ira Helfand. "Climate change and water scarcity will increase risk of nuclear catastrophe in South Asia." Bulletin of the Atomic Scientists 78, no. 4 (2022): 214-217.

[96] Kjølle, Gerd H. "Security of electricity supply in the future intelligent and integrated power system." In Women in Power: Research and Development Advances in Electric Power Systems, pp. 189-207. Cham: Springer International Publishing, 2023; Dubey, Anamika. "Preparing the Power Grid for Extreme Weather Events: Resilience Modeling and Optimization." In Women in Power: Research and Development Advances in Electric Power Systems, pp. 209-243. Cham: Springer International Publishing, 2023.

[97] De Amorim, Wellyngton Silva, et al. "The nexus between water, energy, and food in the context of the global risks: An analysis of the interactions between food, water, and energy security." Environmental Impact Assessment Review 72 (2018): 1-11.

[98] Scouras, James. "Nuclear war as a global catastrophic risk." Journal of benefit-cost analysis 10, no. 2 (2019): 274-295

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