

The Cartography of Global Catastrophic Governance

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Executive Summary

The international governance of global catastrophic risks (GCRs) is fragmented and insufficient. This report provides an overview of the international governance arrangement for 8 different GCR hazards and two drivers. We find that there are clusters of dedicated regulation and action, including in nuclear warfare, climate change and pandemics, biological and chemical warfare. Despite these concentrations of governance their effectiveness is often questionable. For others, such as catastrophic uses of AI, asteroid impacts, solar geoengineering, unknown risks, super-volcanic eruptions, inequality and many areas of ecological collapse, the legal landscape is littered more with gaps than effective policy. We suggest the following steps to help advance the state of global GCR governance and fill the gaps:

- Work to identify instruments and policies that can address multiple risks and drivers in tandem;
- Closer research into the relationship between drivers and hazards to create a deeper understanding of our collective ‘civilizational boundaries’. This should include an understanding of tipping points and zones of uncertainty within each governance problem area;
- Exploration of the potential for ‘tail risk treaties’: agreements that swiftly ramp-up action in the face of early warning signals of catastrophic change (particularly for environmental GCRs);
- Closer examination on the coordination and conflict between different GCR governance areas. If there are areas where acting on one GCR could detrimentally impact another than a UN-system wide coordination body could be a useful resource.
- Further work on building the foresight and coordination capacities of the UN for GCRs.

The international community is underprepared for natural or man-made catastrophes. The recommendations above can ensure that international governance navigates the turbulent waters of the 21st century, without blindly sailing into the storm.

1. Introduction

On January 24th, 2019 the fingers on the Doomsday Clock did not move: they stayed pressed ominously at two minutes to midnight. The clock has been the most captivating attempt to forecast the likelihood of a global catastrophic risk (GCR). It is inherently limited, focusing only on a subset of GCRs: nuclear weapons, climate change and more recently epistemic security. It also does not reflect the governance of different global risks. Understanding how humanity is currently responding to GCRs is fundamental in comprehending how precarious or resilient the world is to calamity.

While global catastrophic risks are becoming increasingly widely known, their governance is understudied. Only a handful of studies have examined whether existing international law arrangements,¹ or the UN,² are fit for addressing existential or global catastrophic risks. Others have attempted to look at the capability of the UN to prevent new risks in an age of AI and converging, powerful technologies.³ These studies have relied on more of a cursory overview of governance, focusing on broad structures and scenario analysis. They have not systematically examined coverage of different hazards and vulnerabilities.

Our report seeks to overcome these limitations by providing the most far-reaching and comprehensive mapping of the governance of global catastrophic risks, including both hazards and vulnerabilities. Our definition of GCRs and existential risks is provided below in Table 1. While our report will focus on GCRs broadly, many of the assessed issues are plausible of becoming existential risks as well.

Table 1: Definitions of GCRs and Existential Risks

Term	Definition
Existential Risk	Any risk that has plausible pathways to cause either human extinction or the drastic and permanent curtailment of societal progress. ⁴ A global collapse could be considered as a lower bound for this, given the uncertainty of how it would unfold in the presence of weapons of mass destruction. ⁵
Global Catastrophic Risk	Any risk that plausibly leads to the loss of 10% or more of global population. ⁶

Our *Cartography of GCRs* demonstrates that several GCR hazards (climate change, nuclear weapons) are covered by international law but usually inadequately. That is, the institutions often lack clear enforcement and compliance mechanisms, and have largely failed to address the underlying collective action problem. Other issues, such as solar geoengineering, catastrophic uses of AI, inequality and some areas of ecological collapse (phosphorous, nitrogen and atmospheric aerosols), are either largely or completely neglected. The governance across GCRs is fragmented, with fractured membership and mandates both within and across different hazards and vulnerabilities. There is no central body empowered to coordinate responses to GCRs nor to foresee them.

2. Approach

In order to achieve a comprehensive overview of global governance arrangements for GCRs it is important to adopt a broad conception of global governance, because otherwise key components may be overlooked, and indications of emergent activity may not be apparent.

A core focus of research and practice in global governance – which is also reflected in this report – justifiably remains the actions of states through international (intergovernmental) organizations and international legal instruments. A report that only focused on these components would, however, present an incomplete picture: a range of other intergovernmental governance activities can contribute to addressing GCRs; and there are relevant activities outside the intergovernmental space. For some GCR areas, the latter currently dominate global governance arrangements.

The significance of different components varies between GCR regimes. This means that the construction of maps and attention paid to different components varies too, but we have also aimed for a level of consistency in presentation. For example: we cover bilateral agreements more extensively in Nuclear Warfare than in other areas because of their high significance in managing global nuclear risk; we cover multilateral expert communities extensively in the Asteroid Impact and Super-Volcanic Eruption areas, because these are more heavily relied upon there.

It is worth making a general observation about the increasing range of issues that need to be addressed through global governance and the challenges this presents:

- Formal intergovernmental governance activities are generally poorly resourced already; their capacity to take on additional tasks and remain responsive to new threats is limited and some are already overstretched.
- Proliferation of global governance activities can disadvantage less well-resourced states, which can struggle to participate in a large number of international forums and processes, representativeness in which is already sub-optimal.
- Increased complexity generally makes governance arrangements more difficult to navigate (one of the reasons mapping work is useful) and increases the transaction costs associated with international cooperation, the likelihood of conflicts and contradictions between rules, and duplication of effort.

Given the extent and complexity of many of the regimes covered in this report, we have separated some more detailed information into Appendix I. Appendix II provides a list of acronyms.

In the report itself, we provide **maps and summary information for individual hazards in global GCR governance**.

These generally follow the GCR categories from GCF's Global Catastrophic Risks 2018 Report. The areas of Biological and Chemical Warfare and Pandemics have been combined, because there are significant overlaps in the global governance activities across these areas that are best illustrated by

handling them together. We have also designated ‘Ecological Collapse’ as a driver of GCR, rather than a hazard. Otherwise we have consistently applied the categorisation of the 2018 report.¹

The mapping of each of these areas is intended to be representative but not exhaustive. We instead provide an overview of key treaties and governance efforts and characterise these as a regime complex: a constellation of institutions addressing the same international issue.⁷ We provide information about the gaps and issues requiring attention in each regime at the end of each hazard section. We also deliver a high-level view of broader GRC governance arrangements under the UN and transnational (networks of non-state actors) actions.

We end with a **summary assessment of GCR governance arrangements** and identification of (priority) lines of research and practical action that could advance the governance of individual GCRs and GCRs collectively.

3. Regime Complexes for Hazards

Hazards are direct threats that could cause global calamity. We drew on both previous GCR reports, as well as consultations with our colleagues to produce the following list of relevant hazards: AI; Asteroid Impact; Pandemics, Biological and Chemical Warfare; Climate Change; Solar Geoengineering; Unknown Risks; Nuclear Warfare, and Super-Volcanic Eruptions. We provide a high-level summary of the governance arrangements of each of these hazards before concluding with an analysis of their effectiveness and gaps.

3.1 AI

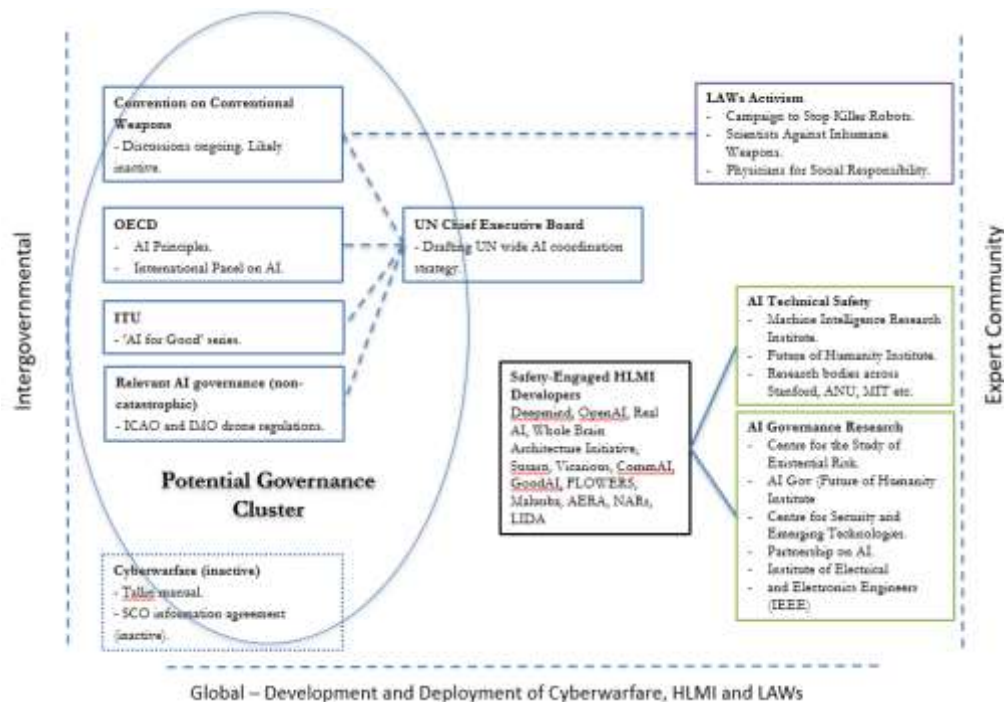


Figure 1: Catastrophic AI Regime Complex

¹ The 2018 GCF Report provides good summary information outlining each of the risk areas, which we do not repeat in full within this report. We would suggest that audiences less familiar with GCRs read the two reports alongside each other.

Within the rising age of AI are hidden disastrous developments. There is an open debate over whether AI systems as a class can be regulated. This is because AI is a set of techniques and sub-disciplines rather than a single, specific technology.⁸ However, there are certain, specific forms of AI systems and end uses could constitute a GCR. These form a discernible, governable cluster. These include:

- *AI-enabled cyberwarfare;*
- *The creation of a misaligned or misused 'High Level Machine Intelligence' (HLMI): a generalised AI system that is roughly equivalent to a human in its cognitive capabilities;*
- *Lethal autonomous weapons.*

Cyberwarfare has essentially no governance at the international stage. There are two minor exceptions. First, is the Tallinn Manual on the International Law Applicable to Cyber Warfare. The Tallinn manual has only been endorsed by NATO member states and provides non-binding advice on the application of international law to cyberspace. Second, is the Shanghai Cooperation Organisation's "Information Security Agreement." This has only six member states and failed to garner sufficient approval from the UN General Assembly. The absence of effective regulation and the proliferation of threats has led some to call for a Cyberwar Convention.⁹ Negotiations for such a body have not begun and are not on the horizon.

LAWs could potentially be covered under the Convention on Certain Conventional Weapons. The Convention has a mechanism—its Additional Protocols—to expand its coverage to new categories of weapons (such as blinding lasers or land mines). However, in practice, negotiations to include LAWs under its remit have been marked by disinterest from great powers. It has yet to yield any success and appears unlikely to do so in the foreseeable future. If it did, the Convention has no ability to enforce its decisions. In the absence of effective international law, civil society has stepped forward in the form of active Campaign to Stop Killer Robots.

The development of HLMI is ungoverned. It is the most neglected area of international AI law.¹⁰ In the absence of explicit regulation, both corporate self-governance and expert community action have filled the void. Many of the firms and bodies creating HLMI are actively engaged in safety work. One 2017 survey of 45 HLMI projects across 30 countries and 6 continents found that only 15 were directly involved in AI safety research.¹¹ Many of these are directly connected to academic and civil society groups working directly on AI technical safety or AI governance. Bodies such as CSER, AI Gov (under the Future of Humanity Institute at Oxford University) are all actively engaged with prominent HLMI developers such as Deep Mind (part of Google) and OpenAI.

There is also no consensus on the governing principles for AI systems. The work of both these expert communities and others has spawned a plethora of AI principles. Most of these encapsulate some common, ambiguous concepts: use of AI for the common good; avoiding harm and the infringement of rights; and; privacy, fairness and autonomy. No clear set of principles reigns supreme, and several tensions exist across them.¹² It is unclear how directly or effectively any of these is for catastrophic AI applications specifically.

There are also several bodies that have some relevance to AI systems but no direct mandate over them. The ITU has been admirably active in promoting AI dialogue through hosting annual 'AI for Global Good Summits' since 2017. Yet the ITU is currently limited to regulating telecommunication systems, such as radio infrastructure; efforts to expand its role in internet governance have been resisted. There are legal arguments that its mandate could extend over many AI systems, but this seems politically unlikely to happen. Similarly, the International Organisation for Standardization (ISO) has established a committee to discuss a program on AI standards, but would have no mandate to address the identified AI problems on its own.

Alongside these bodies is a raft of regulations, working groups and decisions under other fora. Action across the IMO, ICAO, ITU, and other bodies, as well as treaty amendments, such as the updating of the Vienna Convention on Road Traffic to encompass autonomous vehicles, are indicative of this.¹⁰ Most recently, France and Canada have jointly led an initiative to establish a 'International Panel on AP' under

the OECD. This proliferating panoply of AI governance shows some signs of self-organising. The UN System Chief Executives Board (CEB) for Coordination through the High-Level Committee on Programmes has been empowered to draft a system-wide AI engagement strategy. Whether such coordination will be successful is unclear. Moreover, this swell of governance does not capture the catastrophic uses cyberwar, LAWs and HLMI.

Coverage	Expert communities and civil society have been increasingly active in campaigns against LAWs, as well as technical and governance research on HLMI.
Gaps	HLMI currently has no direct governance under international law. LAWs falls under the mandate of Convention on Conventional Weapons but has not been regulated to date. Similarly, attempts to govern cyberwarfare have been either plurilateral and non-binding (Tallin Manual) or unsuccessful (SCO Information Agreement).
Issues Requiring Attention	Whether and how these issues could be addressed in-tandem, such as through a body focused on the military applications of AI. The legitimacy and potential dangers of self-regulation focused HLMI development.

3.2 Asteroid Impact

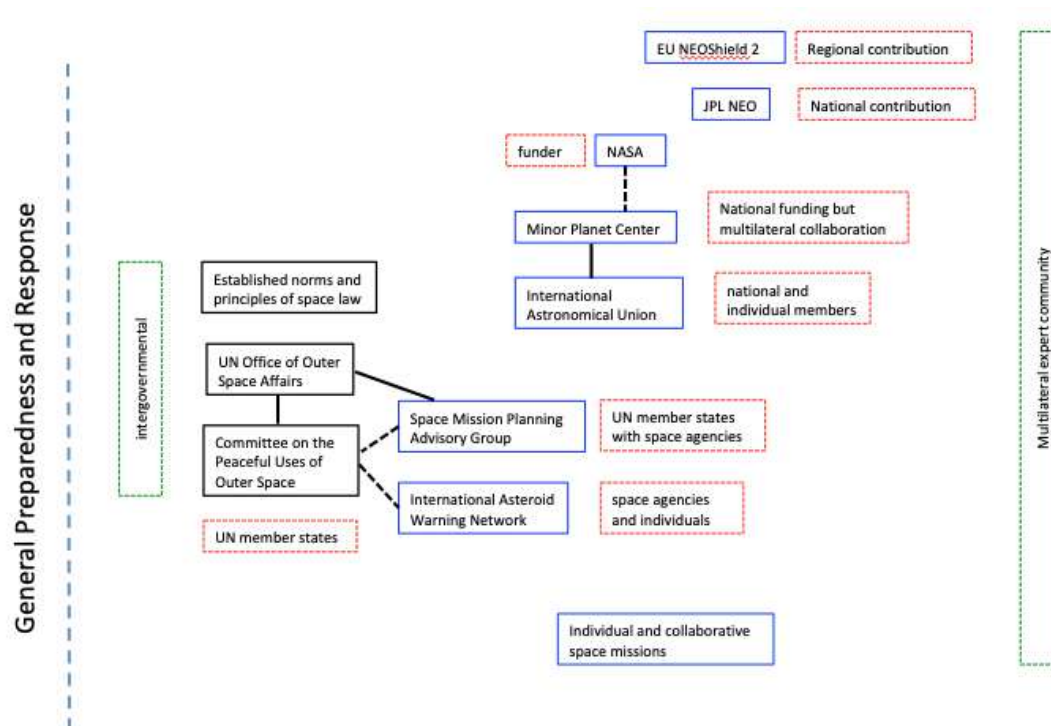


Figure 2: Asteroid Impact Regime Complex

Compared to most other GCRs, global governance for asteroid impacts is minimal, and not particularly complex. There is a reasonable quality of coverage for the more technical aspects of identification, monitoring, evaluation, and early warning, as well as coordination and promotion of research, development and testing of deflection techniques. (Broadly, all of those activities focus on prevention.) There is some coordination of planning around communication, for scenarios in which a 'credible impact threat' is identified, and some connections with civil defence communities (for example as part of the response activities of the Space Mission Planning Advisory Group).

Participants in these governance arrangements understand the seriousness of the threat, particularly where an NEO would be large enough to directly cause a global cooling effect (>1km), and an understanding that smaller NEOs (in the 140m-1km range) could indirectly have global catastrophic impacts as well as being locally catastrophic. There is clear hope that there will be sufficient warning time in advance of a significant Earth impact to boost resilience efforts, however, there is limited extension of the NEO-specific governance arrangements to address preparedness and response. Mostly this will depend on more general global governance arrangements for disaster preparedness and response (see sections 5). Notably, the severe impacts that would need to be prepared for and responded to – those associated with the effects of global cooling and damage to critical infrastructure) will be very similar to those caused by some other GCRs, such as super-volcanic eruptions (section 2.7) and nuclear winter scenarios (section 2.6).

While the UN Committee on Peaceful Uses of Outer Space (COPUOS) and Office on Outer Space Affairs (UNOOSA) are at the core of global governance of asteroid impacts, most of the governance efforts are undertaken by scientific and technical experts in national space agencies, research institutions, and through individual contributions. Some national (particularly NASA-funded) and regional (e.g. the EU's NEOShield 2 Project) efforts have particular significance.

The activities of these other groups connect back to COPUOS and strongly emphasise openness, sharing of data and analysis, and collaborative efforts. This arrangement seems to function well for addressing the technical and prevention aspects of asteroid impact governance, however attention is needed to sustainability and continuity should, for example, a major partner withdraw. (Ensuring continuity has, for example, motivated the establishment of the UNOOSA as a permanent secretariat for the Space Mission Planning Advisory Group.)

Issues around representativeness and equity might in future arise in this governance area, but – currently at least – this seems much less problematic than in other GCR governance areas (such as pandemics), particularly when focusing on the technical and preventative aspects. For representativeness, while the Space Mission Planning Advisory Group, for example, requires the ability to contribute to space missions for participation, and is therefore oriented towards states with space agencies, COPUOS is open to all UN member states (92 are currently members of the Committee) and its recommendations go to the UN General Assembly for discussion and approval. Thus, all UN member states have an opportunity to engage with its work.

For equity, core principles of space law – benefit to humanity and non-appropriation – are established across this governance regime and appear to have broad acceptance and strong normative force. COPUOS has programmes relating to capacity building in space law and for application of space technologies for development goals and during disasters.

It is expected that technological advances will enable mining of NEOs for resources at some point in the future – most likely for use in outer space rather than return to Earth. If this area is substantially financed and/or operated by commercial enterprises, then the practicalities of benefit-sharing will need further consideration. COPUOS will be an appropriate forum for such discussion. COPUOS is also an appropriate point for connection with institutions in the general disaster preparedness and response areas of global GCR governance. The International Asteroid Warning Network (IAWN) is currently working on definitions and terminology for NEOs, and this will include definition of NEO as a natural hazard to feed into the UN Office on Disaster Risk Reduction's updated glossary of natural hazards.¹³

Coverage	There is a good level of coverage for: identification, observation, monitoring, analysis and evaluation, communication, and preventative response. It is limited for: impact preparedness, resilience and response – quality of coverage of these areas will therefore largely depend on general disaster preparedness and response efforts.
Gaps	These are likely to be found in the general disaster preparedness and response efforts.
Issues Requiring Attention	Sustainability and continuity (particularly of non-intergovernmental arrangements). Increasing representativeness and engagement. Increasing role of commercial enterprises.

3.3 Pandemics, Biological and Chemical Warfare

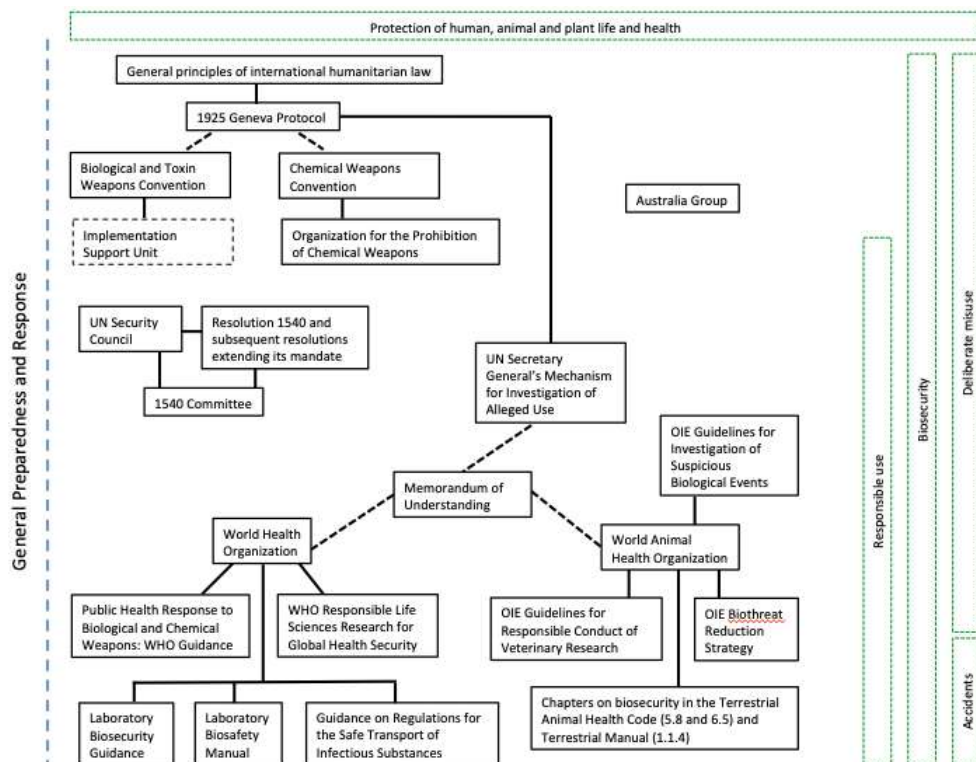


Figure 3: Pandemics, Biological and Chemical Warfare Regime Complex I

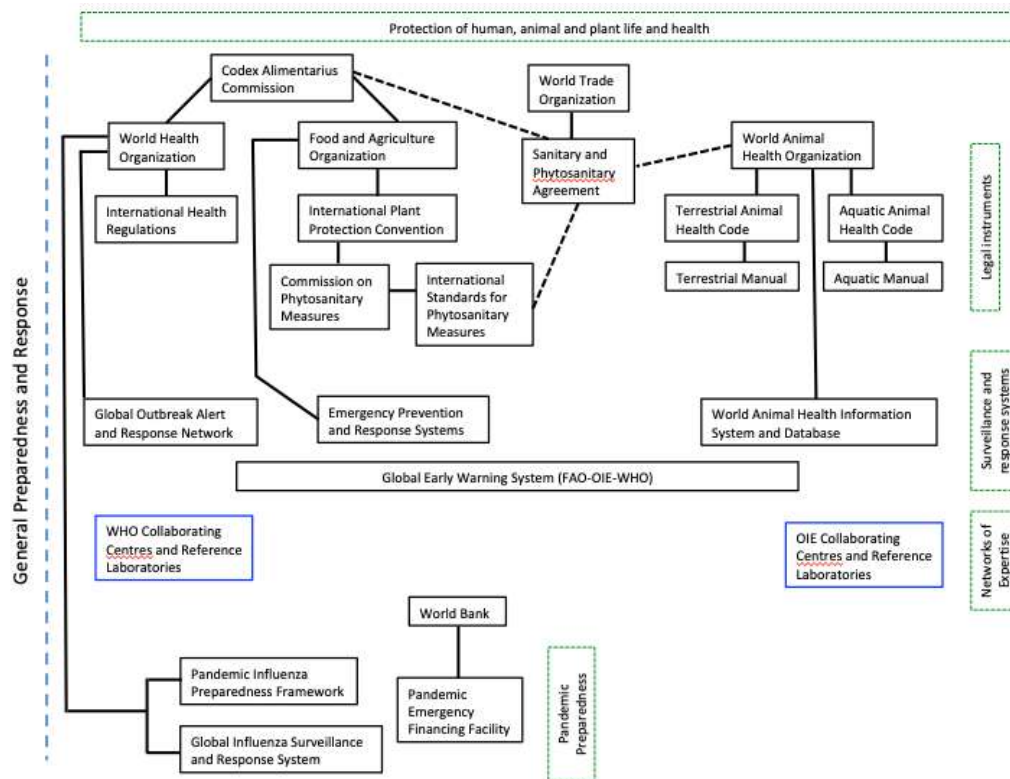


Figure 4: Pandemics, Biological and Chemical Warfare Regime Complex II

In this summary we combine consideration of global governance of biological and chemical warfare and pandemics, because there are significant areas of overlap between the governance arrangements for these two areas, which might not be fully apparent when addressing them separately.

The range of biological risks addressed by global governance is illustrated by the World Health Organization’s ‘biorisk spectrum’:

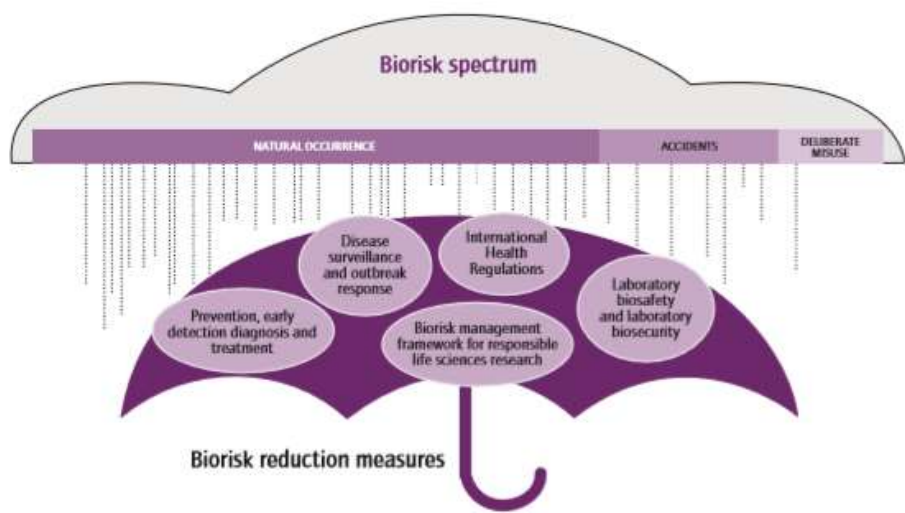


Figure 5: The Biorisk Spectrum and Biorisk Reduction Measures.¹⁴

To this, it is worth adding two further categories to the spectrum: ‘human-induced’ lies between natural occurrence and accidents, and would for example cover anti-microbial resistance as a threat that is ‘natural’ but driven primarily by human action, and might also cover e.g. shifts in geographical range of disease vectors driven by climate change; and ‘deliberate action with benign intent but unintended consequences’ which would sit between accidents and deliberate misuse. This might, for example, relate to release of a biological control agent into the environment without understanding its consequences for health. While this particular image focuses on human health (as the responsibility of the WHO), there are global catastrophic biological risks associated with threats to animal and plant health, and to ecosystems – particularly where these would severely impact food safety and security and key ecosystem services.

Another risk spectrum to be aware of is that which extends across biological and chemical warfare:

Classical chemical weapons	Industrial pharmaceutical chemicals	Peptides and other bioregulators	Toxins	Genetically modified biological weapons	Traditional biological weapons
Cyanide Phosgene Mustard Nerve agents	Aerosols	Substance P Neurokinin A	Saxitoxin Ricin Botulinum toxin	Modified/tailored bacteria and viruses	Bacteria Viruses Rickettsia Anthrax Plague Tularaemia
Chemical Weapons Convention			Biological and Toxin Weapons Convention		
Poison			Infect		

Figure 6: The Comprehensive Prohibition of the Chemical Weapons Convention and the Biological and Toxin Weapons Convention¹⁵

This illustrates the areas of overlapping coverage between the two conventions. While there are now separate conventions for biological and chemical weapons, they were initially addressed together in international governance, and there remain significant connections between the two regimes. The 1925 Geneva Protocol prohibits use of biological and chemical agents in war. It still has relevance because the prohibition on development, production, stockpiling, acquisition and retention in the Biological and Toxin Weapons Convention (BTWC) extends to use through reference to the Geneva Protocol, and because the Protocol is accepted as part of customary international law applicable to all states whether or not they are party to the conventions.

The BTWC and Chemical Weapons Convention (CWC) utilise general purpose criteria prohibiting use of biology and chemistry for non-peaceful purposes. States parties to the conventions have repeatedly emphasised that they are applicable to all scientific and technological advances in relevant fields. Both conventions include provisions promoting peaceful applications – for the BTWC ‘prevention of disease’ is specifically mentioned in this regard, and this is one way in which they connect with other areas of governance of biological risks.

The long-standing international norms against biological and chemical weapons have experienced some challenges, but while there is some concern around potential erosion, these remain strong at present and are central to global governance efforts. There are also some well-recognised areas of weakness in the conventions. The CWC’s provisions relating to the permitted use of some toxic chemicals for law enforcement purposes, has resulted in some ambiguities and divergent interpretations, for example about development and use of riot control agents and incapacitants.¹⁶ The CWC is overseen by the Organization for the Prohibition of Chemical Weapons, which has around 500 staff and an annual budget of around €70 million. One of its core roles is verification activities, which are structured around inspection regimes. The BTWC does not have an associated international organization, and is instead supported by a small Implementation Support Unit of three staff. It also has no verification regime (attempts to negotiate one failed in the early 2000s and are yet to be re-established). This is a significant weakness given the dual-use nature of biological facilities, equipment, materials and research. Both conventions cover areas of rapid scientific and technological advance and their effective implementation by states parties needs to be informed by a good understanding of the risks and opportunities associated with such advances. The OPCW has a Science Advisory Board that undertakes some of this work in regard to the CWC. This is, however, another area in which the BTWC has extremely limited capacity. Civil society groups such as research institutions and science academies undertake efforts in support of science and technology review for the conventions. These efforts are important, but can lack some of the legitimacy of formal processes.

Other international governance relevant to deliberate misuse includes: UN Security Council Resolution 1540(2004), which addresses potential proliferation of biological, chemical and nuclear weapons to non-state actors, and subsequent resolutions which extended its mandate¹⁷, and the associated 1540 Committee, which reports to the Security Council on its implementation; and the UN Secretary General’s Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons.

The OPCW and ISU undertake some activities to support assistance in case of a biological or chemical weapons attack, including through facilitation of requests and offers by their states parties. OPCW has also produced a *Practical Guide for Medical Management of Chemical Warfare Casualties*, directed to medical responders, and the WHO also provides relevant advice, including in its *Public Health Response to Biological and Chemical Weapons* guidance.

There are two other key overlapping areas with broader global governance of biological risks. First, measures for laboratory biosafety and biosecurity, and safety during transport of infectious materials, which form part of the work of the World Health Organization (WHO) and World Animal Health Organization (OIE) contribute to the safeguarding of biological materials that might be misused. Secondly, the systems for surveillance, preparedness and response to disease events overseen by the WHO, OIE and Food and Agriculture Organization (FAO) will play a key role in detection and response

to any deliberate disease outbreaks or chemical attacks. OIE and WHO both have memorandums of understanding around provision of technical support with the UN Secretary-General's Mechanism for Investigation of Alleged Use.

FAO, OIE and WHO also play important roles in prevention and response to accidental releases of biological agents, toxins and hazardous chemicals, including specific guidance on safety in laboratories and during transport.² Their general surveillance, preparedness and response systems will play a key role in detection and response to any outbreaks resulting from accidents or deliberate releases with benign intent but unintended consequences. Provisions of the Convention on Biodiversity and its Cartagena Protocol on Biosafety may also have relevance where damage to health or the environment stems from transboundary movements of living modified organisms.

WHO and OIE have also produced some guidance (*Responsible Life Sciences Research for Global Health Security*; and *Guidelines for Responsible Conduct of Veterinary Research: Identifying, Assessing and Managing Dual-Use*) that is complementary to BTWC states parties' discussions and decisions promoting education and training of scientists in biosecurity responsibilities.

The main international organizations responsible for protection of human, animal and plant life and health (and therefore for addressing threats to them) are the WHO, OIE and FAO. The WHO and FAO also jointly established the Codex Alimentarius Commission to work on international food and feed safety. The disease control activities of each organization centre around specific legal instruments:

- The International Health Regulations (2005);
- The Terrestrial Animal Health Code, Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Aquatic Animal Health Code, and Manual of Diagnostic Tests for Aquatic Animals; and
- The International Plant Protection Convention.

Their work is also supported by surveillance and response systems, expert advisory groups and networks, and collaborating centres and laboratories. The WHO for example has over 800 collaborating centres in 80 countries supporting its programmes, and the OIE has 60 collaborating centres, and a network of reference laboratories focusing on scientific and technical research on over 100 serious animal diseases. Surveillance and response activities, include generalised systems such as the Global Outbreak Alert and Response Network, World Animal Health Information System, and FAO's emergency prevention and response systems (EMPRES); and disease specific systems such as the WHO's Global Influenza Surveillance and Response System.

In response to a breakdown in the international system for sharing of influenza viral samples in 2006/2007, WHO took action to revise its Global Influenza Surveillance Network, enhancing traceability through an Influenza Virus Traceability Mechanism, and establishing the Pandemic Influenza Preparedness Framework, which includes centralised stockpiles of vaccines and treatments for distribution to developing countries during outbreaks of human pandemic potential. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of the Benefits Arising from their Utilization (to the Convention on Biological Diversity) also has relevance to the international sharing of microbial genetic resources, which may interact with global public health efforts.^{18,19}

In recognition of the overlaps between protection of human, animal and plant life and health, the FAO, OIE and WHO have instituted several cooperative initiatives, including – for example: OFFLU a FAO-OIE network of expertise on animal influenzas; and the FAO-OIE-WHO Global Early Warning System

² This guidance is found primarily in: WHO's Manual for the Public Health Management of Chemical Incidents; the WHO Laboratory Biosafety Manual, WHO Laboratory Biosecurity Guidance, and WHO Guidance on Regulations for the Safe Transport of Infectious Substances; and chapters 5.8 and 6.5 of the Terrestrial Animal Health Code and 1.1.4 of the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals.

for Health Threats and Emerging Risks at the Human-Animal-Ecosystems Interface (GLEWS). They also regularly send representatives and provide information to BTWC meetings.

In general, capacity building efforts that focus on building national health system capacities will increase the effectiveness of surveillance and response efforts and reduce the risk of international spread of serious disease outbreaks. Such efforts are supported by states parties to the BTWC, WHO, OIE, FAO among other international organizations and through mechanisms such as the Standards and Trade Development Facility – a partnership between FAO, OIE, WHO, the World Bank and World Trade Organization – that supports access to international markets through development capacities to meet and maintain international standards in food safety, animal and plant health. The World Bank has also increased its activities relating to pandemics over the last few years, including creating a Pandemic Emergency Financing Facility to support countries' outbreak response and limit their international spread.

While these activities appear extensive, there are particular concerns about their effectiveness in relation to capacity to contain and address serious outbreaks of international concern, whatever their origin. The Global Health Security Index – a partnership of the Nuclear Threat Initiative, John Hopkins Center for Global Health Security, and Economist Intelligence Unit – which focuses on assessing global health security capacities, has recently reported, and raised the following key points in this regard:²⁰

1. **National health security is fundamentally weak around the world. No country is fully prepared for epidemics or pandemics, and every country has important gaps to address.**
2. **Countries are not prepared for a globally catastrophic biological event.**
3. **There is little evidence that most countries have tested important health security capacities or shown that they would be functional in a crisis.**
4. **Most countries have not allocated funding from national budgets to fill identified preparedness gaps.**
5. **More than half of countries face major political and security risks that could undermine national capability to counter biological threats.**
6. **Most countries lack foundational health systems capacities vital for epidemic and pandemic response.**
7. **Coordination and training are inadequate among veterinary, wildlife, and public health professionals and policymakers.**
8. **Improving country compliance with international health and security norms is essential.**

Coverage	The breadth of coverage in this area is good: extending across harms to human, animal and plant health and the environment arising from deliberate misuse, accidental release, and natural occurrence of disease. The points of intersection between these areas are also reasonably well covered, and cooperative activity in those areas is increasing. However, there are some significant weaknesses within individual areas and gaps in capacity. There is a good level of engagement of expert communities in the overall work of the OIE and WHO.
Gaps	Significant gaps include: lack of verification for the BTWC; limited capacity for science and technology review for the BTWC; and in national capacities to respond to and contain outbreaks with potential for global spread (such as the core capacities required by the WHO's International Health Regulations). Pandemic preparedness capabilities in particular have been assessed as inadequate by several organizations. This is compounded by the tendency for states to prioritise protection of their own populations

	above effective global responses (as demonstrated during the the 2009 H1N1 influenza outbreak).
Issues Requiring Attention	Particular priority issues include: the need to enhance the ability of international institutions to form good understanding of emerging threats (and opportunities) associated with rapid advances in science and technology, and to adapt governance arrangements to respond effectively to them; and the need for effective action to build global capacities to respond to human pandemic threats and serious disease threats to animals and plants.

3.4 Climate Change

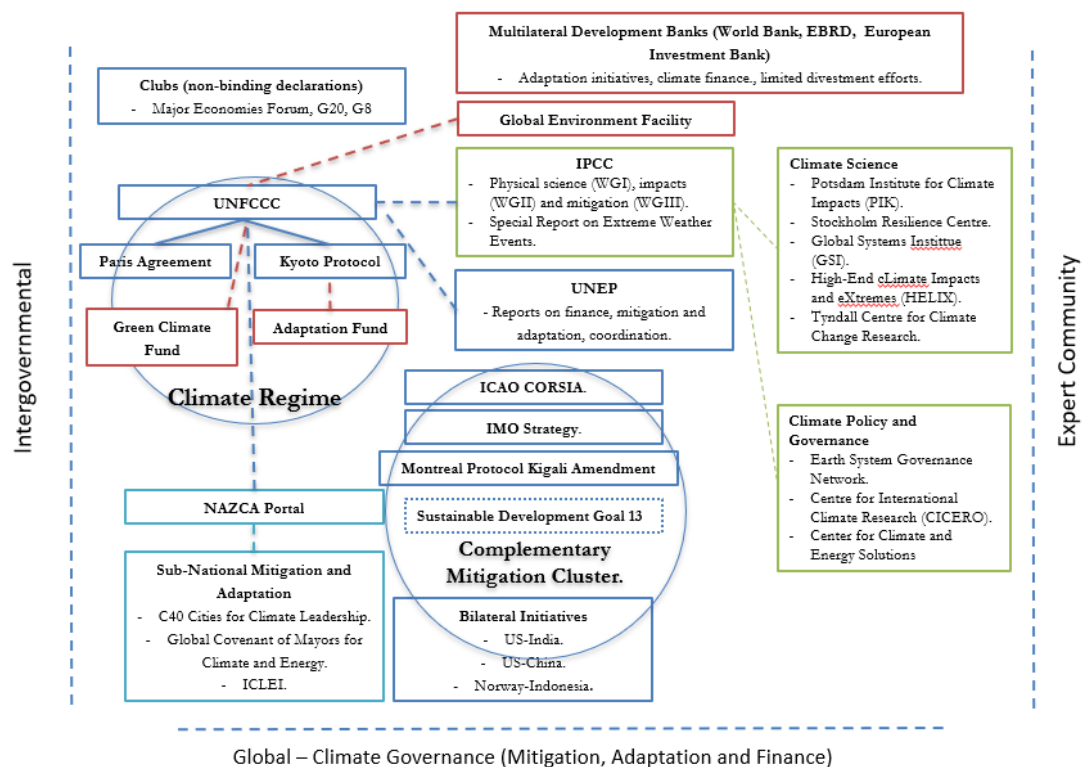


Figure 7: The Climate Regime Complex

The global governance of climate change is one of the most well studied and addressed GCRs under international law. International efforts to address to climate change largely began in 1992 with the creation of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC has since been the lynchpin of international legal efforts to address climate change. It includes provisions on adaptation to climate impacts, mitigation, as well as broader considerations such as capacity building. It also establishes the overarching norms and principles of climate diplomacy, such as ‘common but differentiated responsibilities.

The UNFCCC is the focal point of the climate regime and has been operationalised through two separate protocols:

- *The Kyoto Protocol:* created in 1997, before entering into force in 2005. The Kyoto Protocol contains provisions for monitoring, transparency and verification of emissions, market-based mechanisms (including for international emissions trading and offsetting), financing, and adaptation actions and mitigation targets. It is composed of a two-annex system whereby developing country parties are bound to legally binding emissions reductions targets. Developing countries are not bound by any mitigation targets. The first commitment period of the protocol

lasted until 2013. The 2012 Doha Amendment which extends to the Kyoto Protocol's second commitment period through to 2020 has yet to enter into force due to a lack of ratifying countries.

- *The Paris Agreement*: created in 2015, entered into force in October, 2016. The agreement contains provisions on adaptation, mitigation, market-based mechanisms, loss and damages from climate impacts and multiple other mechanisms. The agreement has set an international target to limit global warming to well below 2°C above pre-industrial levels and pursue efforts to keep it to 1.5°C. It is a pledge-and-review agreement in which countries offer self-determined pledges (nationally determined contributions/NDCs) which are collectively reviewed every five years.²¹ The agreement only offers one additional binding legal obligation to the UNFCCC: to put forward a pledge every five years. Its structure was watered-down to allow for the US to join via an executive agreement rather than Senate ratification.²²

These three institutions constitute the UN climate regime. They have set the primary targets and rules for adaptation and mitigation that other institutions follow and implement. In addition to adaptation and mitigation, there is also governance of loss and damages. This refers to managing the damages incurred by the detrimental impacts of climate change, including slow-onset events, and extreme weather events. In 2013 the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (Loss and Damage Mechanism) was established to govern this area. It offers a dialogue platform for relevant stakeholders and aims to enhance knowledge of risk management and support through finance, technology and capacity building. It does not, as developing countries originally desire, provide rules for financial compensation or remediation.

The climate regime is served by multiple institutions providing financial and intellectual resources. The Green Climate Fund (GCF) is the primary financial organ of both the UNFCCC and the Paris Agreement. The GCF is financed by member-parties to the UNFCCC. It has committed USD\$5.2 billion to 111 projects covering both adaptation and mitigation.²³ The Global Environment Facility was previously the main financier of climate projects, but has now taken a secondary role to the more recent GCF.

The Intergovernmental Panel on Climate Change (IPCC) provides the science basis for international climate governance. It is an intergovernmental scientific process that builds a consensus-based depiction of the science of climate change (working group I), impacts (working group II) and mitigation (working group III). The IPCC provides both assessment reports every five years, as well as special reports both at its own discretion and at the request of the UNFCCC parties.

The IPCC is complemented by the United Nations Environment Programme (UNEP), which has provided an abundance of report on climate governance. These include rolling reports on the mitigation gap, adaptation gap and climate finance.

The proliferation of climate-related law and institutions had a watershed moment in 2015. The Paris Agreement was met with a raft of long awaited climate-relevant policy announcements. These included the Kigali Amendment to phase-out hydrofluorocarbons (HFCs, a potent greenhouse gas and replacement for ozone depleting substances), the Carbon Offsetting Scheme for International Aviation (CORSIA) Under the International Civil Aviation Authority (ICAO) and goal 13 of the Sustainable Development Goals. In 2018 the International Maritime Organisation's (IMO) Marine Environment Protection Committee (MEPC) released an initial strategy on emissions reductions from shipping. This includes an aim to peak emissions from shipping as soon as possible and reduce them by 50% by 2050 compared to 2008 levels. These different initiatives form a cluster of complementary mitigation efforts outside of the central climate regime. However, the efficacy of these initiatives. The SDGs are non-binding and offer no concrete targets or mechanisms. The CORSIA agreement is a voluntary agreement based on offsetting. The IMO strategy offers high-level, non-binding strategic guidance with goals that are not congruent with limiting warming to 2°C.

Mitigation and adaptation activities are also carried out by a range of other intergovernmental bodies. Minilateral forums such as the G20, G8 and Major Economies Forum, have all made multiple statements regarding climate change. These are non-binding political declarations but can help to mould norms and build political momentum.

Adaptation and mitigation actions are occurring through a range of UN agencies and affiliated institutions. These include large climate finance programs from the World Bank, European Investment Bank (EIB), European Bank for Reconstruction and Development (EBRD). Numerous UN agencies, such as the United Nations Development Programme (UNDP) are looking to mainstream climate adaptation and mitigation considerations into their projects and programs.

Actions by subnational and non-state actors are loosely linked to the climate regime. The ‘NAZCA’ platform is a database of non-state and subnational climate actions and pledges maintained by the UNFCCC Secretariat. While it is a useful depository for tracking international efforts, it has no mandate for comparing, critiquing or influencing non-state actions. The actions of sub-national entities such as cities, localities and regions is undertaken through a range of networks including ICLEI (Local Governments for Sustainability, a network of more than 1,750 local and regional governments), C40 Cities for Climate Leadership and the Global Covenant of Mayors for Climate and Energy.

While mitigation and adaptation are well covered broadly, the response to tipping points or global catastrophe is not. Scientific knowledge of tipping points²⁴ and early warning signals²⁵ has progressed substantially. Yet the primary instruments of the climate regime do not have dedicated mechanisms to either induce a rapid response in the case of a looming tipping point, nor to adapt to or recover from a unforeseen climate catastrophe. International climate governance is focused on the average, rather than high-impact, low-probability ‘tail risks’.

A second blind spot is supply side governance. Regulating the extraction, development and refining of fossil fuels offers numerous economic and political advantages.^{26,27} Yet the Paris Agreement makes no mention of fossil fuels. None of the instruments of the climate regime ban the exploration or development of fossil fuels. This has led to recent calls for an international fossil fuel non-proliferation treaty.²⁸

Importantly, the existing governance has not been successful in diverting the world away from dangerous warming. Current emissions trajectories have the world moving towards warming between 2.0-4.9°C by 2100²⁹, with a median of around 2.6-3.1°C³⁰ or 3.1-3.5°C.³¹ The Paris Agreement is unlikely to be able to bend the emissions curve down to 1.5-2°C. Both weak compliance mechanisms, an unproven method of ‘ratcheting-up’ commitments, and the lock-in of emissions-intensive infrastructure by 2020 all undermine the effectiveness of the agreement.³²

Coverage	Wide-reaching coverage of the science of climate change science, impacts and mitigation. Mitigation, adaptation, loss and damages, market-based mechanisms, are covered primarily by the UNFCCC-centred regime, and a raft of other initiatives.
Gaps	Governance of catastrophic or extreme climate change, response to tipping points and early warning signals, stranded assets, fossil fuel non-proliferation.
Issues Requiring Attention	All of the issues outlined above require critical attention. There is already some nascent research on fossil fuel non-proliferation. Research on catastrophic warming and the potential for ‘tail-risk treaties’ are a neglected and high importance priority.

3.5 Solar Geoengineering

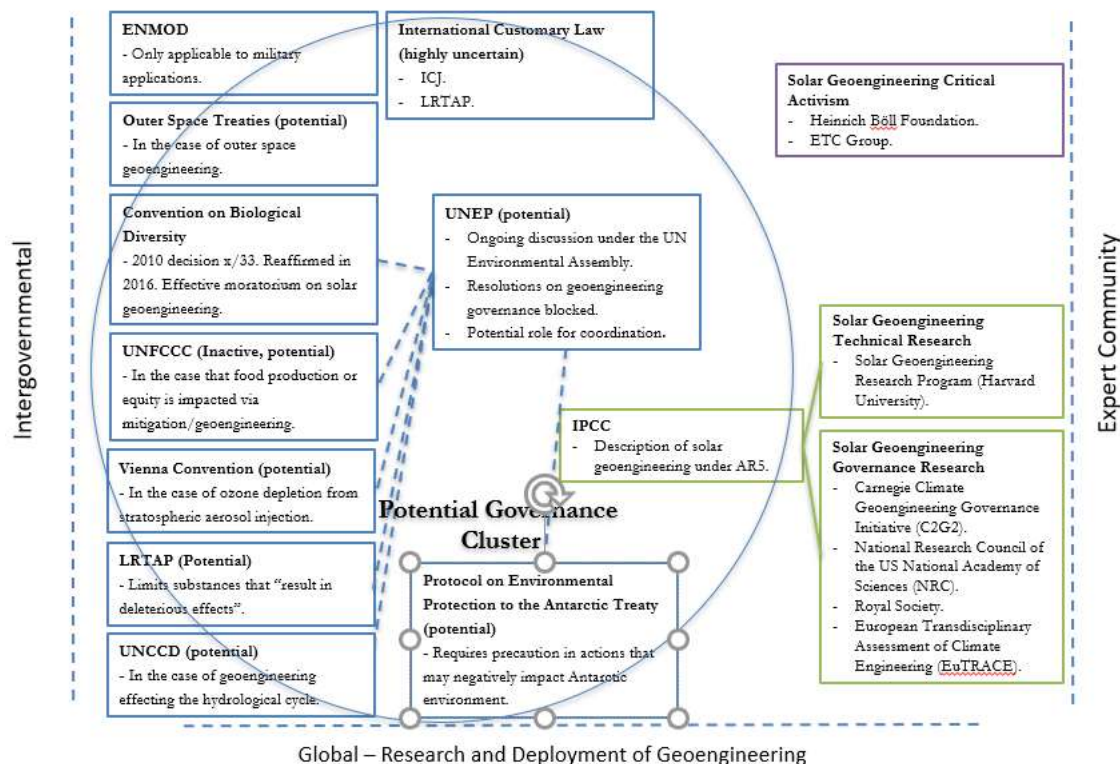


Figure 8: Solar Engineering Regime Complex

There is no explicit international governance of solar geoengineering. As shown in Figure 8, there is a large cluster of treaties which could be relevant. However, these are unplanned, incidental and piecemeal with limited ability for binding application.³³ Thus, there is widespread agreement that there is no distinct solar geoengineering regime and a need for direct governance.^{33–35}

There that norms and rules around environmental impact assessments and harms from transboundary pollution have relevance in guiding the testing and use of such technologies. For example, the International Court of Justice has affirmed that states have a duty under international customary law to avoid major transboundary harm to either the global environmental commons or the territory of other states.³⁶ However, the application of customary international is highly uncertain and unlikely to be effective in overseeing or deterring unilateral or multilateral deployment of solar geoengineering, or even smaller field-tests.³⁵

The most direct piece of solar geoengineering governance is the 1976 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques ('ENMOD Convention'). ENMOD was established in the wake of US attempts to weaponise weather manipulation during the Vietnam War. It appears to have been successful in curtailing research efforts into weather modification. By 1979 US research into the area had declined sharply.³⁷ However, the use of ENMOD is limited for solar geoengineering as it only covers military applications. The preamble of ENMOD actively endorses the potential civilian uses of geoengineering type activities: "... the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations." Given that the majority of use cases of solar geoengineering are likely to be civilian, ENMOD is of restricted utility.

In lieu of any overarching authority, the Convention on Biological Diversity (CBD) has undertaken action on governing geoengineering research and deployment. In 2010 the CBD adopted a decision which could be taken as a de-facto moratorium on large-scale geoengineering. Paragraph (w) of decision x/33 states: "that no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and

biodiversity and associated social, economic and cultural impacts.”³⁸ There is an exception for small scale scientific research studies that can be performed in a controlled environment. The decision was reasserted in 2016, with the caveat that further transdisciplinary research and knowledge-sharing was needed to understand governance options and the potential impacts.³⁴ However, these are non-binding decisions, and ultimately the CBD lacks enforcement mechanisms. It also lacks the participation of one of the most credible potential developers of solar geoengineering: the US.

While international legal arrangements are sparse, there has been a groundswell of work from expert communities. A watershed moment was the 2009 Royal Society Report into governance and ethical issues. This was followed by a 2010 report examining geoengineering regulation by the UK House of Commons Scientific and Technology Committee, a 2011 report by the Kiel Earth Institute, a 2013 piece by the Congressional Research Service in the US and 2015 assessment by the European Transdisciplinary Assessment of Climate Engineering (EU-TRACE).³⁵ Geoengineering was then covered in the IPCC’s fifth Assessment Report (AR5) in 2014 and will be investigated in further depth in AR6.

Geoengineering governance is now a well-established sub-field with academics across multiple institution involved. Technical research has been slower due to social concerns and the previous failure of the 2011 SPICE (Stratospheric Particle Injection for Climate Engineering) program.³⁹ The experiment has sought to field-test a delivery system for stratospheric aerosol injection but faced severe public backlash.

Coverage	Existing governance arrangements are limited to moratoriums and work programmes under different bodies.
Gaps	Almost all SRM activities are not covered under any form of binding international law. This includes rules for deployment, maintenance, innovation or research into the science of geoengineering.
Issues Requiring Attention	The governance of solar radiation management and the unilateral or plurilateral deployment of stratospheric aerosol injection.

3.6 Unknown Risks

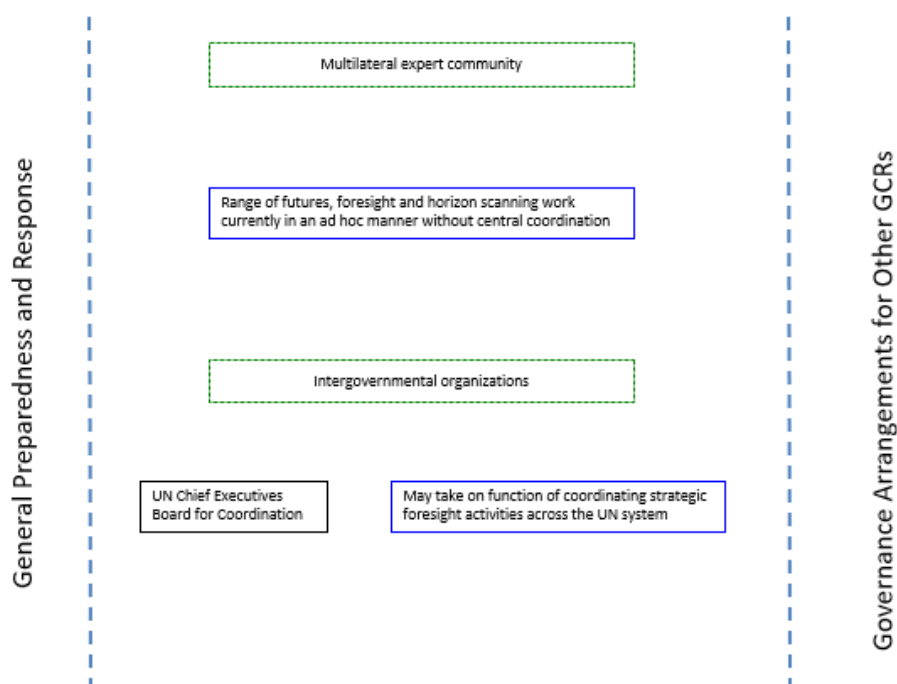


Figure 9: Unknown Risks Regime Complex

There are two particular elements to consider when seeking to identify global governance arrangements for unknown GCRs:

- Processes that might help with identification and analysis of emerging threats.
- General governance arrangements relating to preparedness, resilience and response to GCRs.

And, while we do not know the source and mechanism of unknown risks, we do have some knowledge about the likely objects of protection – that is what it is we seek to protect from any such risk – and therefore which areas of governance we might look to for developing responses should such risks become apparent. For example, whatever the source of risk, we are likely to be interested in protecting human, animal and plant life and health and stability of planetary life support systems.⁴⁰

General GCR governance arrangements are addressed in section 5.

Processes that might help with identification and analysis of emerging threats involve futures studies, foresight and horizon-scanning work, and a range of approaches are available within this. Such activities do have some limitations, and using a combination of approaches, and joining up different exercises can address some of these. They necessarily face their greatest limitations in identifying unknown risks, but there are some techniques for approaching this, for example through use of ‘wild cards’. Involving a wide range of expertise within such processes will also have greater value – particularly because unknown risks may be more likely to occur at the intersection of e.g. different technological areas.

Some national governments and agencies within them regularly undertake foresight activities, often with an aim of identifying potential emerging threats. Such activities are also undertaken by research institutions, science academies, and professional organizations. Global governance of unknown risks could benefit from mechanisms to bring together information from such exercises, so that analysis can be conducted over time and across different countries, regions and sectors.

Several of the international organizations involved in GCR governance conduct simulation exercises which can serve a similar function by helping to identify potential gaps and challenges in responding to emerging threats, and some are exploring the potential use of foresight activities for their work (although not necessarily with the aim of identifying unknown risks, such processes might be adapted to do so). Science and technology review processes associated with some of the organizations may also be a useful basis for such work (although they tend to focus on shorter-term horizons or recent developments). Existing systems for early warning and surveillance may also help to identify novel threats, for example the health impacts of a novel risk may be picked up before the source of the risk is identified.

The UN Chief Executives Board for Coordination, which is made up of the heads of the UN's specialized agencies, funds and programmes, and focuses on fostering coordination and coherence across the UN system, is examining the opportunities for “integrating strategic foresight into its work and... for promoting foresight capacities and fostering collaboration across the system”⁴¹ – if pursued such activities could significantly enhance foresight capacities at the global level.

Coverage	There are some formative but no well-established global governance arrangements for identifying unknown GCRs. Some current surveillance and monitoring systems might support detection of unknown risks. Preparedness, resilience and response will depend on more general GCR governance arrangements.
Gaps	There are gaps across this area. Given the inherent difficulties in identifying and detecting unknown risks, while efforts for this shouldn't be neglected, enhancing general capabilities in preparedness, resilience and response to GCRs would seem to be a higher priority (particularly because of the benefits this would bring to known GCRs governance too).
Issues Requiring Attention	Development and implementation of robust foresight activities for identifying emerging threats. Research on how to enhance the ability of existing surveillance and monitoring systems to spot indications of unknown risks, and communicate with relevant communities to investigate them. Increasing the capabilities of broader GCRs governance.

3.7 Nuclear Warfare

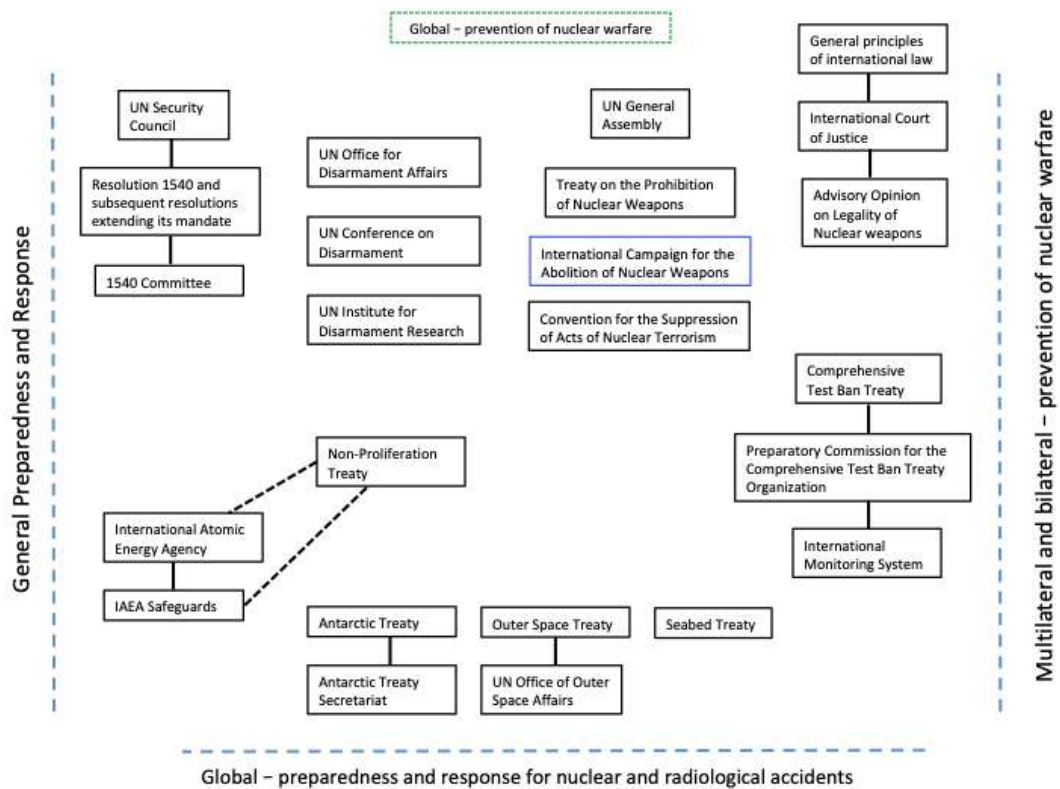


Figure 10: Nuclear Warfare Regime Complex

The extremely severe effects of an all-out nuclear war mean that prevention of such an event is a priority for global governance efforts. If such an event were to occur a response to a range of damage would be needed. Large numbers of immediate fatalities would be expected, particularly where major population centres are targeted (80-95% in a 1-4 km radius)⁴²; there would be significant health impacts on a large scale, compounded by the loss of health systems, staff and infrastructure; widespread environmental contamination; extensive disruption to critical infrastructure; large-scale migration; and probably continued geopolitical instability. If at a sufficient scale to cause ‘nuclear winter’ the associated collapse in global agricultural production would result in global famine and starvation.

Global governance specific to nuclear warfare focuses on:

- Reductions in armaments, with an eventual goal of general and complete nuclear disarmament.
- Preventing proliferation of nuclear weapons and diversion of nuclear materials.
- Measures to stabilise relations between nuclear states, avoid misinterpretation through communication mechanisms, and build confidence through verification and inspection arrangements.
- Creation of nuclear-weapon free zones.

Legal arrangements include:

- Some global legal instruments including a general prohibition on nuclear weapons. These instruments have not all achieved participation of (all) nuclear weapons states, and some are yet to enter into force.

- Some multilateral agreements, generally around creation of nuclear weapon free zones, and involving a set of regional states and accompanied by protocols that commit nuclear weapons states to not testing or using nuclear weapons within those zones.
- Some bilateral agreements, primarily between the US and Russia.

The main international organizations operating in this area include the UN Security Council and General Assembly, Conference on Disarmament, and Office for Disarmament Affairs (UNODA), the Preparatory Committee for the Comprehensive Test Ban Treaty Organization (CTBTO), and International Atomic Energy Agency (IAEA). There are also some multilateral export control groups.

(Specific details on each of the legal instruments, agreements and organizations is provided in Appendix I).

Civil society movements have played a significant role in shaping global governance of nuclear warfare, particularly through: the International Campaign to Abolish Nuclear Weapons (ICANW), which was pivotal in bringing about the successful negotiation of the Nuclear Weapons Prohibition Treaty; the World Court Project that prompted states to take the issue of legality of nuclear weapons to the International Court of Justice; and in establishing nuclear weapon free cities, local authorities, and regions. Expert networks support the work of the IAEA, and the Preparatory Committee of the CTBTO, particularly its monitoring systems.

The humanitarian impacts of nuclear war, including nuclear winter scenarios, have motivated a lot of these global governance efforts, however addressing such impacts is largely outside the focus of these legal arrangements (aside from some generalised commitments to assist states attacked with nuclear weapons).

Some international organizations' work, which relates to dealing with nuclear accidents, may provide a basis for such responses, but it is generally unclear whether this would be possible and how adaptable and scalable such activities might be. This work includes: two IAEA conventions; guidance documents; and networks of emergency responders and other experts. The effectiveness of a response is therefore likely to depend on general global governance for disaster preparedness, resilience and response and emergency management. This is unlikely to be systematic enough to deal with the full range of immediate through to long-term impacts, nor adequate for such a scale of catastrophic event. Such capacities may also have been damaged or impeded by the geopolitical instability that resulted in nuclear war.

Coverage	There are a large number of international legal instruments that address various aspects of the prevention of nuclear warfare. These have had some notable success in reducing armaments, but not yet to a level which is likely to avoid nuclear winter scenarios in all-out nuclear war. There has also been some success in limiting proliferation of nuclear weapons capabilities, though this is regularly challenged. There is a strong international norm against testing, use and possession of nuclear weapons, but no indication that nuclear weapons states will make significant moves towards disarmament in the coming decades, and some indications that the US in particular is moving away from armament restraint. The IAEA does extensive work promoting nuclear safety and security and checking safeguards that back up the Non-Proliferation Treaty, and the Preparatory Committee for the CTBTO is establishing a robust monitoring network. There is very limited coverage of preparedness and response for the impacts of a large-scale nuclear war; this will largely depend on more general global governance arrangements.
Gaps	The most significant gaps are likely to be found in the general global governance of disaster preparedness, resilience and response.
Issues Requiring Attention	Continued pressure needs to be applied to nuclear weapons states to further reduce their arsenals, and subsequently to comply with the international prohibition on nuclear weapons. Within this careful attention will be needed to the stability of deterrence.

There continue to be a few states that fail to comply with non-proliferation arrangements, and / or that express a desire to attain nuclear weapon. As noted in GCF's Global Catastrophic Risks 2018 Report – continued efforts to address regional conflict and geopolitical instability are important.

3.8 Super-Volcanic Eruption

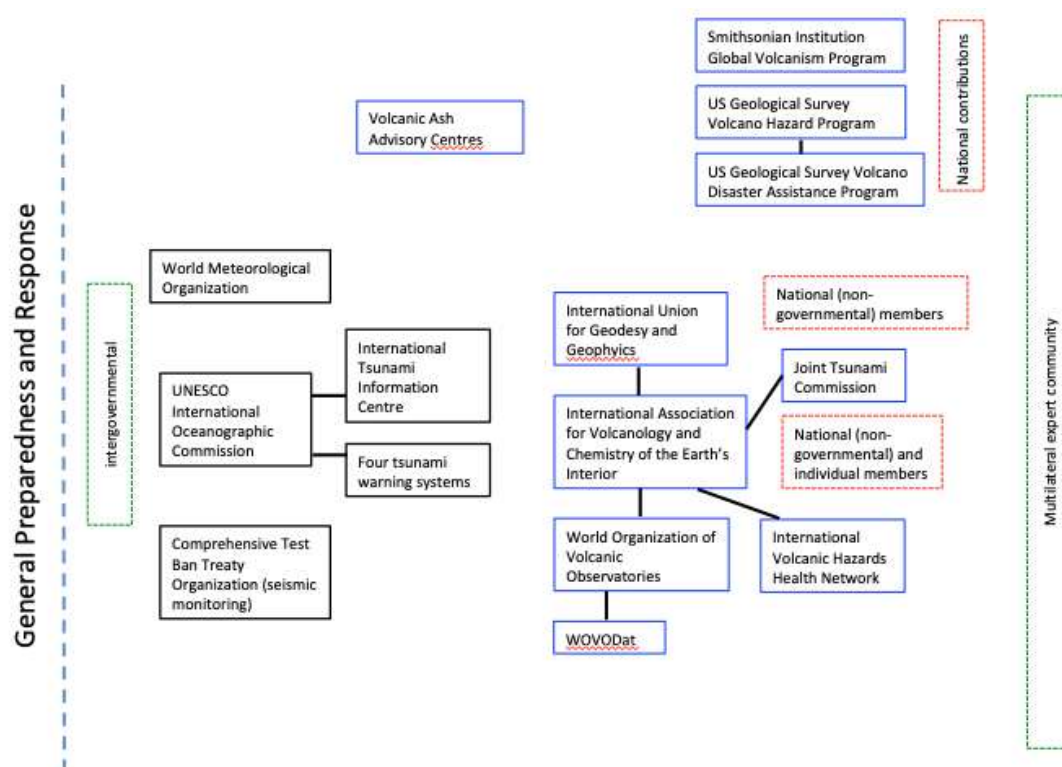


Figure 11: Super-Volcanic Eruption Regime Complex

Global governance arrangements specific to super-volcanic eruptions are sparse and primarily limited to expert networks and collaborating research institutions. These mainly focus on scientific and technical aspects of monitoring and observation. Given limited (if any) prevention capability, most of the activities addressing impacts will fall under general global governance of disaster preparedness, resilience and response. The areas that need to be addressed include: immediate impacts including large-scale loss of life and damage to critical infrastructure (some volcanoes are in areas with local populations of over 5 million, and there could also be resulting Tsunamis affecting other regions); and the longer-term global impacts associated with climate disruptions and resulting agricultural production losses, which could result in widespread starvation.

Super-volcanic eruptions are predicted to occur far more frequently than globally catastrophic asteroid impacts (~1 in 17,000 years compared to ~1 in several hundred thousand years), so the even more limited governance response probably represents a major gap, particularly if the general global governance of disaster preparedness, resilience and response is inadequate. Anyway, improved global coordination of the research, observation, monitoring and early warning of volcanic eruptions would be beneficial.

Central to international coordination efforts is the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI, an association of the International Union of Geodesy and Geophysics). National members of the International Union of Geodesy and Geophysics (IUGG), of which there are 72 currently, and its associations participate in a non-governmental capacity. 52 IUGG

national members participate in of IAVCEI, which also has individual members. Two commissions of the IAVCEI have particular relevance to governance of super-volcanic eruptions: the World Organization of Volcano Observatories (WOVO), which facilitates cooperation between 80 observatories located in 33 countries; and the International Volcanic Health Hazards Network, an interdisciplinary expert network, which collates research and disseminates information on volcanic health hazards and impacts.

A lot of data collection, analysis and dissemination is done by national-based bodies and research institutions such as the Smithsonian Institution's Global Volcanism Program and the US Geological Survey's Volcano Hazard Program. The latter includes a Volcano Disaster Assistance Program, which provides expert support and equipment during volcano crisis events worldwide. WOVODat (linked to the WOVO and hosted by the Earth Institute of Singapore) is also building a global database on volcanic unrest with the aim of improving eruption prediction. Data from seismic monitoring conducted as part of the activities of the Comprehensive Test Ban Treaty Organization may also contribute to data on volcanic unrest.

Nine Volcano Ash Advisory Centres serve the needs of the aviation industry during eruption events. The World Meteorological Organization also provides advice for aviation following eruptions, and may provide information about weather and climate impacts of eruptions. It also has a general disaster risk reduction programme which includes impacts from volcanic eruptions and tsunamis.

Depending on the eruption site, a tsunami may follow a super-volcanic eruption. IAVCEI along with two other IUGG Associations (the International Association of Seismology and Physics of the Earth's Interior, and the International Association of Meteorology and Atmospheric Sciences) have a Joint Tsunami Commission to exchange scientific and technical information with countries that may be affected by tsunamis. The United Nations Educational, Scientific and Cultural Organization (UNESCO)'s International Oceanographic Commission (IOC) has a Tsunami Programme which includes intergovernmental committees for four warning systems (covering the Pacific, Indian Ocean, Caribbean, and North East Atlantic and Mediterranean). The IOC has a mandate to develop a global Tsunami warning system, but this has not yet been established. The International Tsunami Information Centre, associated with the Pacific Tsunami Warning and Mitigation System also carries out programmes for risk assessment and for local community education on preparedness.

UNESCO also has a Geohazards Programme, focusing on associated disaster risk reduction, management and mitigation. While its overview mentions super-volcanic eruptions as events that can threaten humankind, but there doesn't seem to be any work addressing them in the programme.

Coverage	Extremely limited with a dominant focus on information sharing and research collaboration for observation, monitoring and early-warning. It will largely demand on general global governance arrangements for disaster preparedness, resilience and response.
Gaps	There are significant gaps in global governance for super-volcanic eruptions. There is no global organization with a mandate to manage volcanic risk, and no standardised international system for volcano alert levels. Not all sites are adequately monitored. There is little indication of establishment of global norms, e.g. around benefit to humanity. Given limited warning time and no means of prevention of super-volcanic eruptions, substantial attention to preparedness, resilience and response is needed. General disaster governance efforts are unlikely to be adequate.
Issues Requiring Attention	This is a generally neglected area and underfunded area. Sustainability and continuity particularly of non-intergovernmental arrangements. There do not appear to be the same norms around openness and data sharing that there are for near-Earth objects, for example WOVODat has a two year grace period for release of new data.

4. Drivers and Vulnerabilities

Global catastrophic risk is not just a reflection of hazards, but also underlying vulnerabilities. The governance of these vulnerabilities is just as crucial as that of hazards. Yet the coverage of vulnerabilities, both in nature and governance, is far less developed. As a starting point, we will draw on a listing of different contributors to the collapse of previous civilizations⁵. Given that previous societal collapses are the closest recurring analogues we have to GCRs, this is a prudent step. The collapse contributors include environmental degradation, climatic change, declining returns on complexity, declining returns on energy, inequality, oligarchy, as well as external shocks such as disease, warfare and natural disasters. Many of these have already been covered in our cartography, including climate change, (nuclear) warfare, disease, and GCR relevant natural disasters. Others, such as complexity and returns on energy investment, are too nascent and theoretical to be approached directly. This leaves us with environmental degradation, inequality and oligarchy. We will subsume oligarchy under inequality and address these as the two fundamental drivers of GCRs to be examined.

4.1 Inequality

Wealth inequality tends to increase inexorably over time⁴³ and has been linked to both historical societal collapses,⁴⁴ as well as other catastrophes such as World Wars.⁴⁵ This section will explore inequality both in terms of wealth and income inequality within and between countries. There are two separate forms of governance covering these areas:

- Equality-inducing measures within international treaties;
- Governance of mechanisms that drive inequality, primarily tax avoidance and evasion.

The significant global arrangements for poverty alleviation could also be considered as part of international efforts to reduce inequality. This includes both Official Development Assistance (ODA) guidelines under the OECD and the international financial institutions involved with economic development, such as the World Bank and International Monetary Fund. However, the explicit goal of these efforts and infrastructure is poverty alleviation and economic development, not the alleviation of poverty. To the contrary, efforts such as structural adjustment programs likely worsened inequality both within numerous developing countries and the between developed and developing countries.⁴⁶ Instead, we will focus on mechanisms for equity across treaties, and the governance of tax evasion and avoidance.

There is no explicit international governance of income or wealth or income inequality. The closest shadow of direct governance is SDG 10 “Reduce inequality within and among countries”.⁴⁷ While the headline is compelling, the targets are ambiguous and do not set any concrete objectives or measures. Moreover, the SDGs are a non-binding declaration lacking any credible mechanism for ensuring compliance.

Equity considerations are split across multiple treaties and bodies. It has been integral to most environmental treaties. The CBD, UNFCCC and most other multilateral environmental agreements contain numerous capacity building measures as well as financial support provisions for developing countries. This is underpinned by the principles of environmental multilateralism as enshrined in the 1992 Rio Declaration on Environment and Development. Principle 3 states the development must “equitably meet developmental and environmental needs of present and future generations”. Principle 5 notes the need for poverty eradication to avoid major international disparities and principle 6 notes that special priority should be given to developing countries. Mechanisms for capacity building and financial transfer are not just common across environmental agreements, but also in the areas of trade, health and security.

The international system also has a dedicated system to manage drivers of inequality such as tax evasion and avoidance. The United Nations Conference on Trade and Development (UNCTAD), OECD, G20 and IMF all provide estimates of tax evasion both as revenue base erosion and profit sharing. Both the Global Forum on Transparency and Exchange of Information for Tax Purposes and the Multilateral Convention on Mutual Administrative Assistance in Tax Matters (MCMAATM) provide a platform for the exchange of basic tax information.⁴⁸ The framework is unlikely to stem tax evasion or global inequality until more drastic measures, such as global wealth tax, are introduced.⁴⁹

The existing framework to tackle the problem appears to be inadequate. By most measures, global inequality is deteriorating. The typical measurement of the Gini index suggests that inequality between

countries has decreased over the past decade over half. In 2000 it was approximately 44, but had dropped to 39 by 2016.³ This is largely due to the economic rise of major developing countries such as China and India. However, the inequality measured by the Gini index has worsened within most countries over the past few decades, particularly OECD countries.^{43,50} Other measurements portray an even worse situation. The global wealth share of the top 1% has grown from 25-30% in the 1980s to roughly 40% in 2016.⁵ The real figure is likely to be far worse once the hidden treasures of tax havens are considered.⁵¹ This is testament to the ineffectiveness of the existing patchwork that governs inequality internationally.

Coverage	Wealth and income inequality is partially covered by the OECD centred tax regime. This has largely been unsuccessful in addressing the dynamics which exacerbate wealth inequality such as tax evasion and regressive taxation. Many treaties and bodies contain provisions for capacity building and equity, but their success is dubious.
Gaps	The governance of wealth inequality between and within countries is largely a glaring gap in international arrangements.
Issues Requiring Attention	The abolition of channels to inequality, such as tax evasion, as well as mechanisms to mitigate and reverse wealth and income inequality between and within countries.

4.2 Ecological Collapse

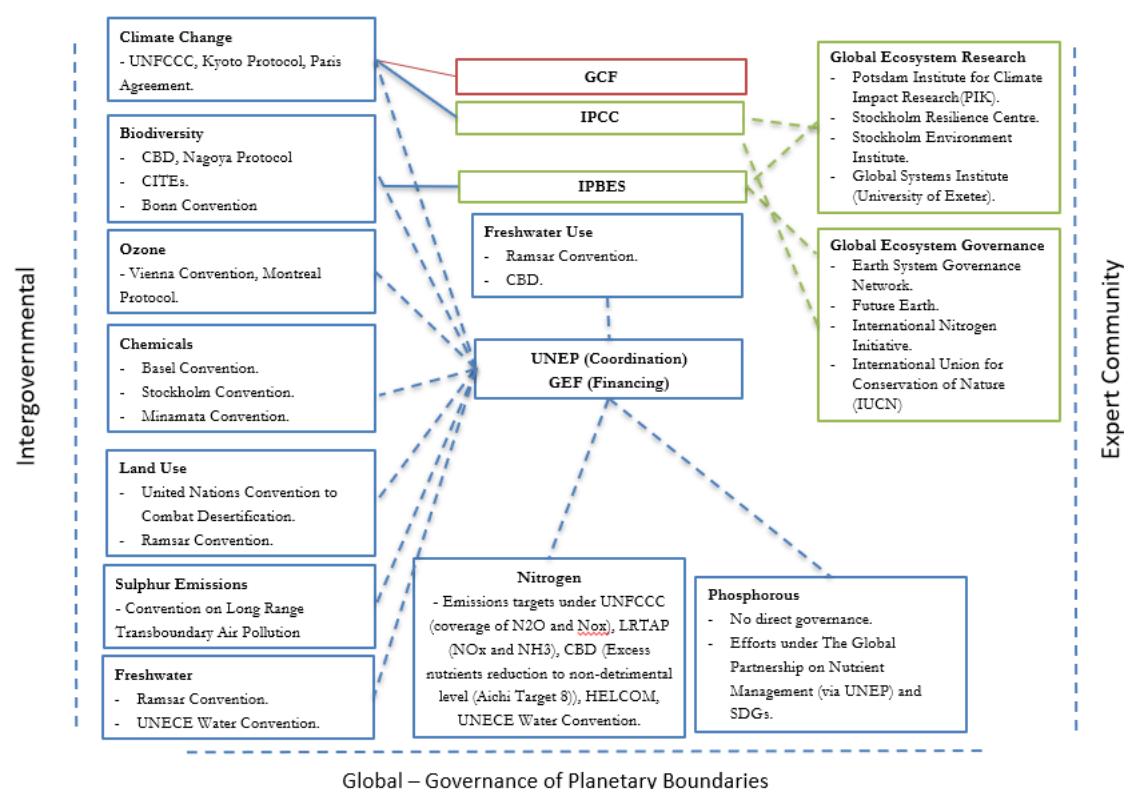


Figure 12: Planetary Boundaries Regime Complex

The loss of ecosystem services is a loss of humanity's resilience. Ecological is a broad phenomenon and it is difficult to draw clear contours around it. We will use the planetary boundaries framework to focus our

³ Authors calculations using World Bank data.

analysis. The framework puts forward nine key global environmental services that constitute a ‘safe operating space for humanity’: climate change, biodiversity loss, the nitrogen cycle, phosphorous, ocean acidification, land use, freshwater, ozone depletion, atmospheric aerosols and chemical pollution.⁵²

It would be impossible to depict and analyse all of the agreements relevant to the governance of ecological collapse. The International Environmental Agreements Database lists “1,300 multilateral environmental agreements (MEAs), over 2,200 bilateral environmental agreements (BEAs), 250 other environmental agreements, and over 90,000 individual country “membership actions””.⁵³ Instead, we will examine the primary instruments governing each planetary boundary. Climate change will be excluded from the analysis, as it has already been investigated.

As shown in Figure 12, the governance of ecological collapse is fragmented institutions. While the diagram depicts governance clusters for each of the planetary boundaries, this is not the case for many. Governance of land-use, freshwater, nitrogen and phosphorous are all deeply fragmented with no overarching convention or framework.

The United Nations Environment Programme (UNEP) acts as the coordinator of UN’s multilateral environmental agreements. In practice, it has struggled to ensure effective collaboration and action between the multitude of agreements.

Most of the governance arrangements are served by the Global Environment Facility (GEF). The GEF acts as the primary financier of international environmental governance. It is financially replenished every 4 years by its 39 donor country members.⁵⁴ It covers forests, international waters, biodiversity, climate change, land degradation, chemicals and others areas, using a variety of grant and non-grant financial instruments.⁵⁴

- *Biodiversity loss*: Biodiversity loss is directly governed by the 1992 Convention on Biological Diversity (CBD) and its 2010 Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. The CBD provides rules and guidance on biodiversity monitoring and reporting, management actions and targets to reduce biodiversity loss. It is scientifically served by the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). The biodiversity regime is complemented by the trade-focused 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the 1979 Convention on the Conservation of Migratory Species of Wild Animals (1979 Bonn Convention).
- *Chemical Pollution*: The international governance of chemical pollution centres upon a trio of treaties: the 2001 Stockholm Convention on Persistent Organic Pollutants; the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; and the 2017 Minamata Convention on Mercury.
- *Ozone*: The international regime is the posterchild for effective environmental multilateralism. It is underpinned by the 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The treaties have been successful in addressing the problem of ozone depletion. The use of ozone depleting substances has been decreasing over the past two decades. Recent satellite data suggests that the hole in the ozone layer is now beginning to shrink and recover. This is largely due to the Montreal Protocols strong non-party mechanism (restricting trade in ozone depleting substances with non-parties) and enforcement mechanism.
- *Atmospheric Aerosols*: The 1979 Convention on Long-Range Transboundary Air Pollution (LRTAP) is the primary international instrument for regulating sulphur emissions.
- *Nitrogen*: There is no explicit governance framework for nitrogen. Instead, there are targets relevant to nitrogen usage split across multiple multilateral environmental agreements. These include emissions targets under the UNFCCC (coverage of N₂O and NO_x), LRTAP (NO_x and NH₃), CBD (excess nutrients reduction to non-detrimental level (Aichi Target 8)), HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission), the OSPAR Commission (Nitrogen oxides or their transboundary fluxes impacting eutrophication), United Nations Economic Commission for Europe (UNECE) Water Convention (nitrate and nitrite concentrations).⁵⁵ The diversity and fragmentation appears to have hindered efforts. A more integrated regime that targets nitrogen pollution origins would be preferable.⁵⁵

- *Phosphorous*: Like nitrogen, the governance of phosphorous is fragmented. There are also non-legal approaches to governing both nitrogen and phosphorous. Foremost is the Global Partnership on Nutrient Management under UNEP.
- *Land-Use*: Land use governance occurs primarily through a duo of legal instruments: the 1994 UN Convention to Combat Desertification and the 1971 Ramsar Convention on Wetlands of International Importance. The Ramsar Convention is largely a pledge and review system, requiring countries to voluntarily submit wetland areas of importance to be regulated under it. Both lack effective enforcement and compliance mechanisms.
- *Freshwater*: As with phosphorous and nitrogen, there is no framework convention or overarching legal instrument to govern freshwater usage and pollution. It occurs through a patchwork including the UNECE Water Convention and the Ramsar Convention.

While not part of the Planetary Boundaries framework, population growth is a key driver of our collective environment impact. Direct governance of population is almost non-existent. The United Nations Department of Economic and Social Affairs (UN DESA) contains a population division. Its role is relegated to demographic research, including population projections and analysis. It has no role in attempting to curb global population growth. Nor does any other UN legal instrument or framework.

Overall, the global governance of phosphorous, nitrogen, atmospheric aerosols, and freshwater are the largest gaps in the protection of planetary boundaries. However, other important oversights exist. There is little effective, coherent governance across boundaries given their deeply interconnected nature. The role of coordination largely falls to UNEP. However, as an under-resourced programme under the UN General Assembly it has often struggled to effectively fulfil this task. As with climate change, there are no mechanisms to govern tipping-points, early-warning signals and the aversion of catastrophic ecological collapses. While there is the general international norm of the ‘precautionary principle’ its exact meaning and implementation has often been hindered by ambiguity.

Like inequality, indicators for ecosystem collapse have been worsening over time. Ecological footprint per capita has trended steeply upwards since 1960, as far back as records go.⁵⁶ The Living Planet Index, a composite measurement for biodiversity, has also been more than halved from 1970 to the present day.⁵⁷ This warning signals suggest that despite that the governance of planetary boundaries while abundant is porous and inadequate.

Coverage	Adaptation and mitigation of ozone depleting substances are effectively governed by the Vienna Convention and Montreal Protocol. Biodiversity loss and climate change are well, but ineffectively, covered by the UNFCCC and CBD regimes. Chemical pollution is partially covered by a cluster of treaties including the Stockholm and Basel Conventions.
Gaps	The governance of most planetary boundaries is currently fragmented and focused on mitigation, adaptation and science. The governance of phosphorous, nitrogen, atmospheric aerosols, and freshwater are all largely neglected. There is little to no governance of catastrophic tipping points, or interactions between earth systems.
Issues Requiring Attention	Tail risk treaties across environmental issues, as well as early warning and tipping point responses both within and across planetary boundaries.

5. The Broader GCR Governance Landscape

5.1 UN Governance

The UN contains broader governance arrangements that are relevant for GCRs. First and foremost is the UN Office for Disaster Risk Reduction (UNDRR), which oversees the implementation of the International Strategy for Disaster Reduction. This includes efforts to build resilience, coordinate emergency responses to disasters and ensure effective recovery. The Sendai Framework for Disaster Risk Reduction 2015-2030 was endorsed by the UN General Assembly in 2015 and provides four priorities

and seven targets for action. However, both UNDRR and the Sendai framework are focused on non-GCR, natural hazards. Their efficacy and mandate in reducing GCRs is questionable. It was preceded by the Hyogo Framework for Action, which covered disaster risk reduction guidance for the decade of 2005-2015.

Disaster management splintered across a wide range of bodies including WMO and WHO. The WHO includes decisions and frameworks for disease outbreaks, risks in emergencies, poisoning, displaced peoples, complex emergencies (caused by warfare or the large-scale movement of people) and other areas. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) contains numerous programs to assist countries in reducing both climate and disaster risk. These include activities on geohazard risk reduction, water hazard risk reduction, school safety, tsunamis, disaster risk reduction in UNESCO designated sites and crisis management and post-crisis transitions. Actions in these areas focus on knowledge provision and capacity building.

There has been nascent, unsuccessful discussion of introducing intergenerational governance mechanisms into the UN. This includes the 2012 push for an Ombudsman for Future Generations (to be located under the Secretary General) at the Rio+20 negotiations and the Secretary General's 2013 report on 'Intergenerational solidarity and the needs of future generations'. The former was unsuccessful and the latter is a non-binding review. Successfully introduced mechanisms for intergenerational governance in the UN could have profound implications for GCR management and foresight under the UN.

Coverage	The UN broadly covers disaster risk through the UNDRR and Sendai framework. While these incorporate preparedness, emergency response and risk reduction, they are primarily focused towards natural disasters. The UN Security Council has the mandate to cover risk reduction and response for conflict-based risks.
Gaps	Foresight of GCRs and existential risks, as well as preparedness, response and recovery to worst-case scenarios, and risk reduction and response for and across anthropogenic GCRs are all lacking.
Issues Requiring Attention	Mechanisms to coordinate foresight, recovery, response and reduction of GCR, particularly anthropogenic risks.

5.2 Transnational Governance

Taking an appropriately broad perspective on what is encompassed by global governance (as outlined in section 2), there are various actors and activities beyond formal inter-governmental arrangements. Those significant for the global governance of GCRs include:

Individual Experts and Communities of Expertise

For all GCRs a key need is for greater understanding about the risks and prevention, mitigation and response options. There is, therefore, a substantial need for contributions from a range of experts to address these areas. While some international organizations and treaty processes – and national delegations engaging with them – have some in-house expertise, this is not always the case and may well be insufficient, particularly when it comes to more extreme risk scenarios.

In some GCR governance regimes experts are quite well integrated in inter-governmental arrangements at various levels of formality (for example in protection of human, animal and plant health). In others, clear spaces have formed in which expert communities play a key support role and help to address gaps (for example in science and technology review associated with the Biological and Toxin Weapons Convention). In yet other regimes, inter-governmental activity is very limited and expert communities form the core of global governance efforts (for example in the area of super-volcanic eruptions).

Expertise may be provided on an individual basis or collectively through a representative organization (such as a scientific academy) or through participation in collaborative networks (such as laboratory networks supporting the work of the World Health Organization).

An extensive range of disciplinary and practical experience and expertise is needed for effective governance of GCRs. Careful consideration of how to bring knowledge together across fields and integrate it in governance activities is needed, and there is substantial scope for further research and practical action in this regard. This needs to be worked out – and exercised – well in advance of potentially catastrophic events otherwise interventions are more likely to fail. (For example, the lack of integration of social science in international responses to the 2014 Ebola outbreak has been recognised as a key failure point).⁵⁸

The role of experts in global governance is not unproblematic. There need to be ways of assuring quality, relevance and legitimacy of expertise – which can be assisted, for example, by use of peer networks. Setting particular standards for qualifications and level of experience can be useful, but can also privilege participation by certain groups and limit representativeness. Transparency about potential conflicts of interest is also important. Sometimes relationships between expert communities and formal governance processes are difficult – as at other levels, international policy making is not always evidence-based and policy-makers can have unrealistic expectations about expert input, e.g. expecting a level of certainty that is not achievable. Resourcing of expert communities can also present challenges – being transparent about funding sources is important, and political difficulties could arise where one particular state or agency is the main source of support for a group. Some expert groups will be disadvantaged by lower levels of funding and access to other resources such as facilities, equipment or data. As identified in some of the regime summaries, there is also a need to be alert to the sustainability of governance efforts where they rely heavily on expert activities and to have contingency plans should a key funding source be withdrawn.

Civil Society Organizations (CSOs)

CSOs also perform valuable roles in relation to GCRs governance, some of which we highlight here (with further examples provided in some of the regime summaries):

- Form the basis for transformative global campaigns to address particular GCRs – the role of the International Campaign for the Abolition of Nuclear Weapons in advancing negotiations towards the 2017 Treaty on the Prohibition of Nuclear Weapons is a prominent recent example.
- Provide a route of connection from the local to global levels both in bringing citizens' concerns to the attention of international bodies and in connecting international governance initiatives back to local action. (For example, this can be seen in the connection between local communities and the work of the UN Office for Disaster Risk Reduction in the Community Practitioners Platform for Resilience).⁵⁹
- Provide global connectivity between groups with aligned interests and concerns, amplifying their ability to effect action transnationally. Examples include the Global Fossil Fuels Divestment Movement⁶⁰, and the Mayors for Peace initiative, which brings together over 7,800 cities worldwide to engage citizens in pursuit of nuclear disarmament.⁶¹

Industry Organizations and Transnational Corporations

Companies also have a significant role to play in global governance. This is frequently perceived / portrayed negatively because it often relates to pursuit of private commercial interests above wider global benefits (and there are some notable cases of this). However, it is important not to exclude such organizations from GCR governance efforts – although it may be necessary to moderate their influence. They are impacted by global governance, and they can have significant influence on it. If designed well governance arrangements might motivate companies' contributions to GCR prevention and response.

One model for such action is the UN Global Compact, this invites companies to align their behaviour with international principles and goals in human rights, sustainable development, and social and environmental protection. It currently has participation from over 9,500 companies worldwide. Such a model could be used to raise awareness among companies about GCRs and the behaviours they might adopt to help to address, or at least avoid contributing to such risks.

Companies may engage with global governance on an individual basis or collectively – often through industry organizations. They can play a key role in international standard-setting and in harmonization

and interoperability efforts that extend industry-wide. Such work might help to address some gaps in GCR governance, and as with other transnational actors, they may be able to motivate state action to address particular issues in a timely manner.

The re-insurance industry also has key interests in disaster prevention, resilience, response and recovery, and is another significant actor within GCR governance efforts.

Media Organizations

Media organizations are not necessarily deliberate actors in global governance but they can have significant influence on it and have a key role in GCR governance in terms of communication and public understanding. This role and how it can function constructively during catastrophic events needs to be better understood. Some international organizations provide guidance and/or training on communication during crises (these tend to be aimed at their staff rather than toward media organizations) and have media offices. The UN Office for Disaster Risk Reduction has some relevant initiatives, including a Global Media Network for Disaster Risk Reduction and a Guide for Journalists Covering Disaster Risk Reduction: Disaster through a Different Lens, however further global guidance developed by and for media organizations around responsible communication and good practice in disaster reporting could have great value. This situation is, of course, complicated by extensive use of social media and continued research efforts in this area are needed, alongside general work to increase public understanding of risk and awareness of misinformation.

There is substantial scope for improving knowledge and understanding about the full range of transnational governance actors and activities that can support GCR governance, building towards recommended actions to enhance and sustain their contributions.

Areas for Future Research

- More detailed mapping / database of transnational actors across the GCR governance space;
- Case studies of effective practice and areas for shared learning across regimes;
- Legitimacy of transnational actors in global governance;
- Priority which should be given to transnational governance activities within GCR governance;
- Whether there is a relationship between higher levels of transnational actors and activities and effectiveness of governance;
- Whether there is a need to be concerned about areas in which transnational actors dominate GCR governance efforts.

6. Recommendations: Is the International Governance of GCRs Fit for Purpose?

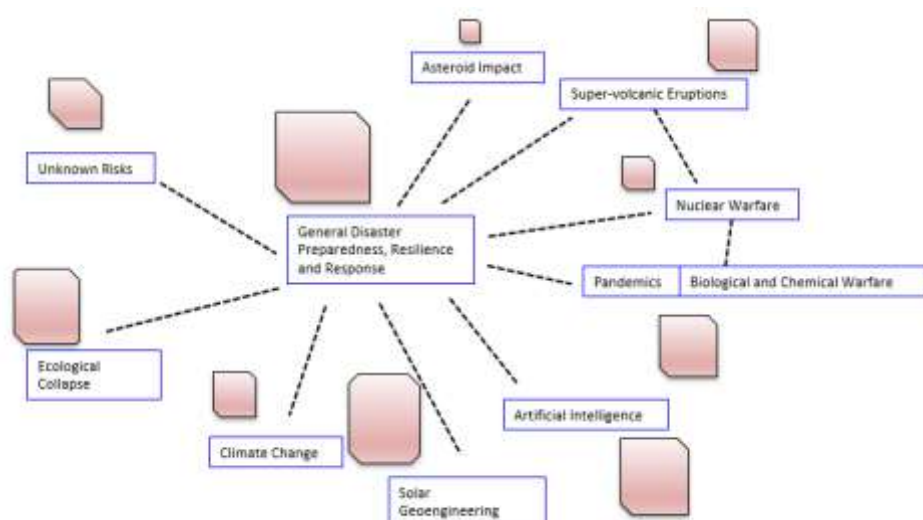


Figure 13: The Gap Gradients in Global GCR Governance



Gap gradient: we are using this as a rough indication of the scale of the governance gaps in each area. In some areas there are:

- Extensive governance arrangements, but also a large amount of additional work that is needed (pandemics, biological and chemical warfare; climate change; ecological collapse);
- Extensive but vulnerable governance arrangements, reliant on cooperation of a few key players (nuclear warfare);
- Limited governance arrangements at present, but those that are needed would not need to be particularly complex (solar geoengineering; super volcanic eruptions);
- Limited but reasonably comprehensive governance arrangements (asteroid impact);
- Limited governance arrangements, and quite complex governance needs (artificial intelligence).
- Finally, the largest gap gradient applies to general disaster, preparedness, resilience and response arrangements / 'broader GCRs governance'. This is because the significance of gaps in this area is heightened because effective governance of all of the individual GCRs is reliant on these general components. For example – resilience and response to the damage to global agricultural production and food supplies common to scenarios of asteroid impact, super-volcanic eruption and nuclear winter, all rely on these broader governance arrangements.

Figure 14: Gap Gradient Summary Description

Figure 13 provides an overview of the gaps in different areas of governance (the larger the red icon the more significant and pressing the gap). Figure 14 delivers an overview of the state of the gaps in the different governance areas. This, combined with the summary boxes for each hazard and driver provide a detailed guide to the strengths and weaknesses of coverage and areas of neglect for each area of GCR governance. This is a high-level overview of the landscape of GCR governance. Each of these areas, particularly larger areas such as ecological collapse and climate change, would require extensive reports of their own to provide a comprehensive analysis.

Something that has not been possible to assess but which may form a vital component of global GCRs governance is the extent to which intelligence agencies cooperate to share information relevant to emerging risks, and whether there are particular actions that might be taken both to improve such coordination and enable some of the information to be shared with other international governance actors.

We suggest the following steps to help advance the state of global GCR governance and fill the gaps:

- Work to identify instruments and policies that can address multiple risks and drivers in tandem;
- Closer research into the relationship between drivers and hazards to create a deeper understanding of our 'civilizational boundaries'. This should include an understanding of tipping points and zones of uncertainty within each governance problem area;
- Exploration of the potential for 'tail risk treaties': agreements that swiftly ramp-up action in the face of early warning signal of catastrophic change (particularly for environmental GCRs);
- Closer examination on the coordination and conflict between different GCR governance areas. If there are areas where acting on one GCR could detrimentally impact another than a UN-system wide coordination body could be a useful resource.
- Further work on building the foresight and oversight capacities of the UN for GCRs. More information is needed to investigate whether and on what basis comparison can be made between different areas of GCRs governance in order to prioritize efforts to address gaps. Improving general global preparedness, resilience and response efforts seems an obvious priority because it will contribute to addressing multiple GCRs. However, it is less clear how to prioritize between specific actions that address particular gaps for individual risks.

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8. Appendix I: Governance Tables

AI

AI Problem	Current Coverage in International Law	Extent of Coverage	Quality of Coverage
<i>AGI</i>	N/A	N/A	N/A
<i>AI-aided Cyberwarfare</i>	Partly covered by the Shanghai Cooperation Organization's (SCO) <i>International Information Security Agreement</i> .	6 member states (China, Kazakhstan, Kyrgyzstan, Russia, Tajikistan and Uzbekistan). The Agreement was forwarded for adoption at the UN General Assembly but never garnered sufficient agreement.	Lays out broad rules for cooperation (information exchange, sharing of practice, coordination of policies) to combat information crime and information war.
	Partly covered by the <i>Tallinn Manual on the International Law Applicable to Cyber Warfare</i>	Only been formally supported by a small number of NATO countries.	Only details how existing international law (particularly humanitarian law and state responsibilities) is applicable to cyberspace. Unbinding, academically written guidelines. An update was overseen by the NATO Cooperative Cyber Defence Centre of Excellence and released in 2017.
<i>LAWs</i>	<i>Convention on Certain Conventional Weapons</i> .	125 member states.	Has the mandate to adopt a protocol restricting the use of LAWs but has yet to do so. Possesses no compliance or enforcement mechanisms.

Asteroid Impact

INSTRUMENT / ORGANIZATION	PARTICIPATION	STATUS	MANDATE / SCOPE
United Nations Office on Outer Space Affairs (UNOOSA)		Inter-governmental	Serves the Committee on Peaceful Uses of Outer Space. Also serves as the permanent secretariat of the Space Mission Planning Advisory Group (SMPAG), and cooperates with the International Asteroid Warning Network (IAWN).
General international legal principles governing outer space, particularly those relating to benefit of humanity		Global	Of the five sets of principles UNOOSA outlines for governance of outer space, two – use for benefit of humankind, and non-appropriation – are particularly relevant in the context of governance of asteroid impacts.
Committee on the Peaceful Uses of Outer Space (COPUOS)	92 member states plus observer organizations	Inter-governmental	Works to advance the peaceful uses of outer space and to maximise the benefits from applications of space science and technology, which include applications relating to identification, observation and monitoring of near-Earth object, and related communication and education activities.
Space Mission Planning Advisory Group	17 state-based space agencies, and the European Space Agency. IAWN is an ex officio member and UNOOSA and the IAU are observers.	Multilateral expert community with UN endorsement	Responsible for establishing the framework, timeline and options for any response to a significant near-Earth object with potential for Earth impact. It will also provide a focal point for international mitigation planning in the event of a credible potential Earth impact being identified by IAWN.
Impact Disaster Planning Advisory Group			Provides a link between the SMPAG and civil defence communities to coordinate and support mitigation planning.
International Asteroid Warning Network (IAWN)	17 official signatories to the IAWN Statement of Intent	Multilateral expert community	A virtual network, that works to identify, evaluate, observe and monitor potentially hazardous near-Earth objects. Collects, analyses and openly shares data. Also develops

			recommendations about plans and procedures that might be used in governmental responses to credible impact threats.
International Astronomical Union (IAU)	Over 11,000 individual members and 80 national members.	Multilateral expert community	The general purpose of the IAU is to advance astronomical sciences and their understanding by the public. Its most relevant work related to NEOs is its Minor Planet Center.
Minor Planet Center		Multilateral expert community	The Center receives nationally-based funding, but is part of the International Astronomical Union, and serves as an international clearing house for asteroid data.
NASA Planetary Defense Coordination Office		Multilateral expert community	Conducts applied scientific research to address the threat of near-Earth object impacts, contributing to detection, monitoring and early-warning and to response in the form of deflection techniques. Also coordinates with other space agencies, particularly through IAWN, SMPAG and COPUOS.
EU NEOShield-2 Project		Multilateral expert community	Conducts research on deflection techniques for near-Earth objects.
NASA JPL Center for NEO Studies		Multilateral expert community	Conducts observation and analysis of near-Earth objects, include orbit calculations and impact hazard evaluations.

Pandemics, Biological and Chemical Warfare

AREA(S)	INSTRUMENT / ORGANIZATION	PARTICIPATION / STATUS	MANDATE / SCOPE
Prevention of misuse	General principles of customary international law	Customary international law applies to all states.	The prohibition on use of biological and chemical weapons also has the status of customary international law. There are also customary law prohibitions on the use of weapons of an indiscriminate nature and of weapons that cause unnecessary suffering or superfluous injury.
Prevention of misuse	1925 Geneva Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare	142 states parties	Prohibits the use of chemical and biological weapons in warfare.
Prevention of misuse	Biological and Toxin Weapons Convention (BTWC)	183 states parties	Prohibits the development, production, stockpiling, acquisition and retention (and through reference to the 1925 Geneva Protocol – use) of microbial agents or toxins and associated weapons, equipment or means of delivery for non-peaceful purposes (Article I). Also promotes the exchange of such materials, equipment and related scientific and technical information for peaceful purposes (Article X).
Prevention of misuse	Implementation Support Unit (ISU)	The ISU does not have the status of an international organization. It has 3 staff.	Provides administrative support for meetings, and supports implementation and confidence-building activities associated with the BTWC.
Response to misuse	Assistance, Preparedness and Response overseen by Implementation Support Unit		The ISU provides information about assistance, preparedness and response, and assists with connections with other international organizations and NGOs relevant to this work, including through participation in the WMD Working Group of the UN Office of Counter-Terrorism
Response to misuse	Assistance and Cooperation Database associated with the BTWC	Voluntary participation	Established by the Seventh Review Conference of the BTWC, offers of and requests for assistance and cooperation (linked to Article X of the Convention) can be made through this database.

Prevention of misuse	Confidence Building Measures associated with the BTWC	For 2017, 76 states parties submitted a CBM. 58 states parties have never submitted a CBM.	The Confidence Building Measures (CBMs) are a form of information exchange between states parties, designed to improve transparency in activities relevant to the objectives of the Convention. There is an expectation that states parties will make annual submissions of information. There are current six CBM areas: research centres and laboratories and national biological defence research and development programmes; outbreaks of infectious diseases and similar occurrences caused by toxins; encouragement of publication of results and promotion of use of knowledge; legislation, regulations and other measures; past activities in offensive and/or defensive biological research and development programmes; and vaccine production facilities.
Prevention of misuse	Chemical Weapons Convention (CWC)	193 states parties	Prohibits development, production, acquisition, stockpiling, retention, transfer or use of chemical weapons. Required declaration and destruction of existing chemical weapons stocks, with strong verification measures. Includes inspection mechanisms to check that chemicals are only used for peaceful purposes.
Prevention of and preparedness and response to misuse	Organization for the Prohibition of Chemical Weapons (OPCW)		Oversight of the implementation of the Chemical Weapons Convention, staffing and supporting its verification and inspection functions, and promoting the peaceful use of chemistry.
Prevention of misuse	UN Office of Counter Terrorism		Supports coordination of global counter-terrorism related activities across the UN system, including those relating to terrorist uses of biological or chemical weapons.
Preparedness for misuse	OPCW Ensuring Preparedness		The OPCW offers support to states parties for national protection programmes covering preparedness and response capabilities for possible chemical warfare attacks. It also facilitates requests for assistance between states parties, and oversees a Voluntary Assistance Fund.
Preparedness for and response to misuse	The Protection Network		A group of governmentally nominated experts that advise OPCW on emergency response activities.

Response to misuse	OPCW Responding to Use		The OPCW facilitates mechanisms for request and receipt of assistance in case of chemical weapons attacks, and has capacity to carry out investigations into alleged use.
Response to misuse	Practical Guide for Medical Management of Chemical Warfare Casualties		A guide for medical responders commissioned by the OPCW.
Prevention of misuse	Australia Group	40 states and the European Union	The Australia Group is a multilateral export control forum focusing on preventing the proliferation of biological and chemical weapons.
Prevention of misuse	Common Control Lists		The Australia Group has five, regularly updated, common control lists of items for which export licensing arrangements should be in place. (Chemical Weapons Precursors; Dual-use chemical manufacturing facilities and equipment and related technology and software; Dual-use biological equipment and related technology and software; Human and animal pathogens and toxins; and plant pathogens.)
Prevention of misuse	UN Security Council Resolution 1540 and subsequent resolutions extending its mandate	Passed unanimously by UN Security Council members	Decides that all states are obliged to take action to prevent proliferation of nuclear, chemical and biological weapons and associated means of delivery, and commits states not to undertake any activities that would support non-state actors that aim to acquire, develop, produce, transfer or use such weapons.
Prevention of misuse	1540 Committee	15 members from the UN Security Council	A subsidiary body of the UN Security Council, initially established by Resolution 1540(2004) with its mandate extended by subsequent resolutions, and currently running until 2021. Tasked with reporting to the UNSC on progress with implementation of the Resolution(s).
Response to misuse	UN Secretary General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons	Any UN member state can request investigation of alleged use.	Can carry out investigations into alleged use of biological and chemical weapons on request of any UN member state, to establish whether there has been any breach of the 1925 Geneva Protocol.
Response to misuse	Memorandum of Understanding between OIE and the UN Secretary-General's Mechanism		OIE agrees to provide relevant technical support and guidance to the UN Secretary General's Mechanism with contact coordinated through the WMD Branch of the UN Office of Disarmament Affairs.

Response to misuse	Memorandum of Understanding between WHO and the UN Secretary-General's Mechanism		WHO agrees to provide relevant technical support and guidance to the UN Secretary General's Mechanism with contact coordinated through the WMD Branch of the UN Office of Disarmament Affairs.
Response to misuse	WHO Initial Clinical Management of Patients Exposed to Chemical Weapons: Interim Guidance Document (2014)	Initially valid until January 2015, does not appear to have been replaced yet.	Guidance for health workers on how to identify cases of chemical weapons exposure, protect themselves while treating exposed patients, and method and protocols for treatment and decontamination.
Emergency response	WHO International Programme on Chemical Safety: Chemical Incidents and Emergencies		This programme provides guidance to countries on public health preparedness and emergency response to chemical incidents.
Emergency response	WHO 2009 Manual for the Public Health Management of Chemical Incidents		Provides general guidance on prevention, preparedness, detection, response and recovery from chemical incidents. It examines case of addressing deliberate chemical release incidents in Box 4 of its Emergency Planning and Preparedness section.
Response to misuse	Public Health Response to Biological and Chemical Weapons: WHO Guidance (2004)		This guidance includes information on the different agents that might be used and how to assess threats from them; recommendations on public health preparedness and response; and information about relevant international law and international sources of assistance.
Response to misuse	World Health Assembly Resolution 55.16 (18 May 2002) Global public health response to natural occurrence, accidental release or deliberate use of biological and chemical agents or radionuclear material that affect health		Directed the WHO Director-General to continue efforts to provide guidance on public health aspects of deliberate use of chemical or biological agents to cause harm, explore the possibility of developing new tools to assist global public health responses, and continue to collaborate with other relevant international organizations and laboratory networks in this work.
Response to misuse	WHO Chemical and Biological Working Group		Established to share information, experience and activities and promote a coherence approach and foster collaboration and cooperation across the WHO and with its regional offices.
Addressing biological threats	OIE Biological Threat Reduction Strategy		Strategy recognising and outlining the interactions between OIE's activities in response to natural, accidental and deliberate biological threats to animal and veterinary public health.

Response to misuse	OIE Guidelines for Investigation of Suspicious Biological Events		A short guidance document to support national veterinary services in building their preparedness and capacity to identify suspicious biological events, and collaborate across sectors in investigations.
Prevention of misuse	OIE Guidelines for Responsible Conduct of Veterinary Research: Identifying, Assessing and Managing Dual-Use		This guidance aims to: raise awareness about the dual-use implications of veterinary research; prompt reflection on responsible conduct throughout the research process; and facilitate development of institutional and national guidelines on how to address such issues.
Prevention of misuse	WHO Responsible Life Sciences Research for Global Health Security		This guidance relates to responsible conduct of life sciences research to reduce risks of accidents, unintended consequences and deliberate misuse.
Biosafety and biosecurity	WHO Laboratory Biosafety Manual	Voluntary standards	Provides standards and guidance relating to laboratory biosafety practices, procedures, equipment and training, including for high containment laboratories that deal with pathogens of highest risk to human health. Aims to protect health and safety of workers and the wider public from accidental release of pathogens from laboratories.
Biosecurity	WHO Biorisk Management: Laboratory Biosecurity Guidance	Voluntary standards	Provides standards and guidance for preventing the unauthorised access, loss, theft or misuse of 'valuable biological materials' including pathogens and toxins, from laboratory facilities.
Biosafety	WHO Guidance on Regulations for the Transport of Infectious Substances	Voluntary guidance	Summarises provisions from modal regulations on the transport of dangerous goods, which apply to infectious substances. Promotes the safe transport, handling and use of infectious materials, in order to protect human health.
Protection of human health	World Health Organization (WHO)	193 member states	Works for the global protection and advancement of human health.
Protection of animal (and human) health	World Animal Health Organization (OIE)	182 member states	Works to limit the international spread of serious animal diseases while minimising the impacts on international travel and trade.
Protection of food security and agricultural production including plant and animal health	Food and Agriculture Organization (FAO)		Works to promote food security, food safety, and sustainable agricultural production worldwide.

Protection of human health	International Health Regulations (2005)	193 states parties	The regulations are designed to limit the international spread of severe human disease outbreaks while minimising disruption to international travel and trade. It includes requirements to establish and maintain 'core capacities' to support such work.
Protection of human health	IHR Emergency Committees		These expert advisory committees support the work of the WHO Director-General in developing temporary recommendations for addressing public health emergencies of international concern.
Protection of animal (and human) health	Terrestrial Animal Health Code	Applied by OIE member states	Outlines standards and procedures (including for risk analysis; trade controls; and notification of outbreaks of serious animal diseases) to minimise the risks of international transfer of animal disease, and maintaining safety in trade in animals and animal products. The standards designed for use by veterinary services, laboratories and those involved in border management for import of animals and animal products.
Protection of animal (and human) health	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals	Applied by OIE member states	The Manual includes some general guidelines and others specific to particular animal diseases, supporting diagnosis and surveillance of serious animal diseases. It is targeted at veterinary laboratories and national veterinary services. Chapter 1.1.4 provides standards for biosafety and biosecurity in veterinary laboratories.
Protection of animal (and human) health	Aquatic Animal Health Code	Applied by OIE member states	Outlines standards for aquatic animal health and welfare, designed to enable early detection, diagnosis, surveillance and response to serious aquatic animal disease outbreaks, while maintaining safe trade in aquatic animals.
Protection of animal (and human) health	Manual of Diagnostic Tests for Aquatic Animals	Applied by OIE member states	Provides standards for diagnosis of serious aquatic animal diseases (those listed as notifiable in the Aquatic Animal Health Code).
Protection of plant health	International Plant Protection Convention		Aims to control the international spread of plant pests and pathogens while minimising unnecessary disruption to international travel and trade.
Protection of plant health	Commission on Phytosanitary Measures		Supports the development and updating of International Standards for Phytosanitary Measures associated with the

			IPPC. It also supports related implementation and capacity building activities.
Protection of plant health	International Standards for Phytosanitary Measures (ISPMs)		These are standards developed within the framework of the IPPC for use by its states parties in assessing and managing risks from plant pests and pathogens.
Protection of human health	WHO Pandemic Influenza Preparedness Framework		Established centralised stockpiles of vaccines and treatments for distribution to developing countries during pandemics. Also facilitates sharing of viral samples with and within the Global Influenza Surveillance and Response System.
Protection of human health	Communicating Risk in Public Health Emergencies: A WHO Guideline for Emergency Risk Communication, Policy and Practice		Evidence based guidance on risk communication during emergencies, developed in response to challenges faced during the 2014 Ebola outbreak.
Protection of human health	Global Outbreak Alert and Response Network (GOARN)		The network links together scientific and technical capabilities of WHO member states, laboratory networks, and relevant international organizations and civil society organizations able to support WHO in outbreak response. WHO performs a coordinating role for the network.
Protection of human health	Global Influenza Surveillance and Response System (GISRS)	Institutions from 115 WHO member states participate in the System.	Brings together laboratories, collaborating centres and national influenza centres, to support epidemiological surveillance and preparedness and response activities.
Protection of human health	WHO collaborating centres	Over 800 institutions in 80 WHO member states.	The WHO collaborating centres are research institutes that support work across its full range of programmes.
Protection of human health	World Bank Pandemic Emergency Financing Facility		A funding mechanism to support developing countries in timely response to disease outbreaks, limiting the potential for international spread.
Protection of animal (and human) health	OFFLU (OIE / FAO Network of Expertise on Animal Influenzas)		A joint initiative of the Food and Agriculture Organization and World Animal Health Organization to bring together global expertise for the identification emerging influenza strains in animals and management of associated risks.
Protection of animal (and human) health	World Animal Health Information System / Database (WAHIS/WAHID)		An online system that processes disease surveillance data in real-time and provides early warning and monitoring information to OIE member states.

Protection of animal (and human) health	OIE collaborating centres and reference laboratories		The OIE collaborating centres are research institutions that support its work in particular animal health topics; the OIE reference laboratories support its work in relation to specific animal diseases.
Protection of human, animal and plant health	Global Early Warning System for Health Threats and Emerging Risks at the Human-Animal-Ecosystems Interface (GLEWS)		A collaborative initiative between the FAO, OIE and WHO, that focuses on detection, assessment, prevent and control of emerging disease threats.
Protection of food security and agricultural production including plant and animal health	FAO Emergency Prevention and Response Systems (EMPRES)		These systems, including EMPRES-Food Safety, EMPRES-Plant Protection, and EMPRES-Animal Health, support preparedness, early warning and response activities for FAO member states.
Protection of food safety, animal and plant health	World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures		Limiting sanitary and phytosanitary measures applied to trade to those that are scientifically justified. The Agreement refers to the standards of the Codex Alimentarius, International Plant Protection Convention and World Animal Health Organization as a good basis for international standards in these areas.
Intersecting areas of international law	Convention on Biological Diversity		The objectives of the Convention are: conservation of biodiversity; sustainable use of its components; and fair and equitable sharing of the benefits arising from utilisation of genetic resources. It includes an Article on the handling of biotechnology.
Intersecting areas of international law	Cartagena Protocol on Biosafety		A protocol to the Convention on Biological Diversity that establishes a system for advanced informed agreement for transboundary movement of living (genetically) modified organisms. It aims to protect biodiversity, with risk to human health also taken into account.
Intersecting areas of international law	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of the Benefits Arising Out of their Utilization		A protocol to the Convention on Biological Diversity providing a framework for prior informed consent of the provider state for access to genetic resources within its territory. This has implications for global public health research because may be applied to pathogens that pose serious human, animal or plant disease risks.

Climate Change

Instrument	Status	Extent of Coverage	Quality of Coverage
<i>2015 Paris Agreement on Climate Change</i>	Non-binding treaty.	187 parties have ratified the treaty. The US has ratified the treaty but submitted an intention to withdraw, which will take place on	The agreement has the enshrined goal of limiting global average temperature rise to “well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C”. However, current efforts put the world on course for a temperature rise of 2.0-4.9°C by 2100. ²⁹ It has a purely facilitative compliance mechanism and no enforcement mechanisms. Targets are self-selected, resulting in a ‘pledge and review’ structure. The agreement seems highly unlikely to meet its own lofty goals due to the problem of lock-in of fossil fuel infrastructure, inadequate provisions, and a reliance on the unproven efficacy or pledge and review. ³²
<i>1995 Kyoto Protocol</i>	Binding treaty.	192 member parties.	The Kyoto Protocol contains provisions for monitoring, transparency and verification of emissions, market-based mechanisms (including for international emissions trading and offsetting), financing, and adaptation actions and mitigation targets. It is composed of a two-annex system whereby developing country parties are bound to legally binding emissions reductions targets. Developing countries are not bound by any mitigation targets. The first commitment period of the protocol lasted until 2013. The 2012 Doha Amendment which extends to the Kyoto Protocol’s second commitment period through to 2020 has yet to enter into force due to a lack of ratifying countries.
<i>1992 UNFCCC</i>	Binding treaty.	197 parties have ratified the treaty.	The UNFCCC provides a broad framework for climate negotiations. Key weaknesses include an inflexible annex system, and consensus decision-making due to an ability to adopt its original rules of procedure. ⁶²

<i>2015 Kigali Amendment to the 1987 Montreal Protocol</i>	Binding treaty.	81 parties have ratified the treaty. The Kigali Amendment entered into Force on the 1 st of January 2019.	Sets an 85% phase-down of the production and consumption of hydrofluorocarbons (HFCs) by 2036 for developed countries and by 2046 for developing countries.
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Solar Geoengineering

Instrument	Status	Extent of Coverage	Quality of Coverage
<i>1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)</i>	Binding treaty. Entered into force in 1978.	78 parties have ratified the convention.	Only covers the military use of geoengineering techniques. Hence its utility in governing civil uses of geoengineering for climate change mitigation is severely limited.
<i>1992 UNFCCC</i>	Binding treaty.	197 parties have ratified the agreement	Does not have any direct mandate over geoengineering activities, although some scholars have claimed it could claim legal ownership over the issue, including through amendments to the Convention (which would require a three-quarters majority vote).
<i>Amendment to the 1996 Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter ('London Protocol')</i>	Amendment to a binding treaty.	The amendment is currently not in force due to a lack of ratifying parties. Two-thirds of the 87 members of the Protocol are required.	<p>The amended article 6bis stipulates that "Contracting Parties shall not allow the placement of matter into the sea from vessels, aircraft, platforms or other man-made structures at sea for marine geoengineering activities listed in Annex 4, unless the listing provides that the activity or the sub-category of an activity may be authorized under a permit". It is effectively a ban on marine geoengineering.</p> <p>Unlikely to be relevant to solar geoengineering unless methods to use the oceans for significantly impacting albedo are developed.</p>
<i>1992 Convention on Biological Diversity</i>	Decisions under a binding treaty.	196 member parties. All members of the UN excluding the US have ratified the treaty.	2010 CoP decision x/33 sets a moratorium on “ <i>climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts</i> ”. There is an exception for small-scale tests conducted in a controlled manner.
<i>United Nations Environment Programme (UNEP)</i>	Decisions blocked under a coordinating agency of the UN General Assembly.	193 member states.	Potential site for governance and coordination. No compliance or enforcement mechanisms.

Nuclear Warfare

PURPOSE	INSTRUMENT / ORGANIZATION	PARTICIPATION	STATUS	MANDATE / SCOPE
Disarmament ⁴	1972 Strategic Arms Limitation Treaty	United States and Soviet Union	Superseded by later agreement	Capped size of their intercontinental ballistic missile and submarine-launched ballistic missile forces
Disarmament	1972 Anti-Ballistic Missile Treaty	United States and Soviet Union	US withdrew in 2002; no longer operational.	Set limits to development and deployment of anti-ballistic missile systems
Disarmament	1974 Vladivostok Agreement	United States and Soviet Union		Stated intention to continue negotiating strategic arms limitation
Disarmament	1979 Strategic Arms Limitation Treaty II	United States and Soviet Union	Never entered into force	Set additional limits or bans on certain types of missiles and systems.
Disarmament	1987 Intermediate Range Nuclear Forces Treaty	United States and Soviet Union	US withdrew in August 2019	Destruction of ground based ballistic and cruise missiles with 500-5000 km range, and associated launchers and support structures.
Disarmament	1991 Strategic Arms Reduction Treaty (START)	United States and Soviet Union		Agreed reductions to strategic nuclear weapons to set numbers within 7 years, including strong verification.
Disarmament	1992 Lisbon Protocol (to START)	The four 'nuclear capable' successor states to the Soviet Union (Belarus, Kazakhstan, Russia, Ukraine)		Made them each a party to START.
Disarmament	1993 Strategic Arms Reduction Treaty II	United States and Russia	Has not entered into force	Established additional limits and reductions to strategic arms, complementary to START.
Disarmament	2002 Strategic Offensive Reductions Treaty	United States and Russia	Replaced by NewSTART	Commitment to reducing deployed strategic nuclear warheads to 1,700-2,200 each by 31 December 2012.
Disarmament	2010 New Strategic Arms Reduction Treaty (NewSTART)	United States and Russia		Commitment to further reductions in strategic arms by February 2018. Incorporating various verification measures including the right to conduct a set number of inspections each year.
Disarmament	2017 Treaty on the Prohibition of Nuclear Weapons	33 parties, 79 signatory states	Not yet entered into force	Prohibits the development, testing, production, manufacture, acquisition, possession, stockpiling, transfer, receipt, use or threat of use, stationing, installation, or deployment of nuclear weapons or other nuclear explosive devices.
Disarmament	General principles of international humanitarian law	Any principles of customary international law apply to all states		The International Committee of the Red Cross defers to the opinion of the international court of justice in relation to how these principles apply to nuclear weapons

⁴ This refers to efforts for limitation and / or reduction of stockpiles of nuclear weapons through to general and complete disarmament.

Disarmament	1996 Advisory Opinion (of the International Court of Justice) on the Legality of the Threat or Use of Nuclear Weapons			The threat or use of nuclear weapons generally contrary to established international law (particularly international humanitarian law); definitive ruling on use in cases of “extreme circumstances of self-defence” not possible; there is a general obligation to pursue nuclear disarmament.
Disarmament	UNGA A/RES/71/67 Nuclear Disarmament Verification	25 participants in the Group of Governmental Experts		Requests report by the UN Secretary General on development and strengthening of nuclear disarmament verification, and created a Group of Governmental Experts to consider the role of verification in supporting nuclear disarmament efforts.
Disarmament	Report of the Secretary General on Nuclear Disarmament Verification (A/72/104)			
Disarmament	Final Report of the Group of Governmental Experts to Consider the Role of Verification in Advancing Nuclear Disarmament (A/74/90)			
Disarmament	International Campaign to Abolish Nuclear Weapons (ICANW)	541 non-governmental organizations from 103 countries		Having successfully campaigned for the negotiation of an international treaty prohibiting nuclear weapons, ICANW now focused on adherence to and implementation of the Treaty.
Disarmament	United Nations Office on Disarmament Affairs			Supports UN member states in efforts to achieve general and complete disarmament.
Disarmament	United Nations Conference on Disarmament	65 member states. Other UN member states can take part in its activities as ‘non-member states’.		International forum for disarmament negotiations.
Non-proliferation ⁵	1946 First Resolution of the United Nations General Assembly	The UN had 55 member states in 1946		Established a commission to Deal with the Problems Raised by the Discovery of Atomic Energy to develop specific proposals in various areas including elimination of atomic weapons.
Non-proliferation	1968 Nuclear Non-Proliferation Treaty (NPT)	191 states parties (not India, Israel, Pakistan or South Sudan, and uncertainty about whether North Korea is a party)		Parties agree to: prevent proliferation of nuclear weapons and technology, promote cooperation in peaceful uses of nuclear energy, and commit to goal of nuclear disarmament. There are differential requirements for nuclear and non-nuclear weapons states
Non-proliferation	1980 Convention on the Physical Protection of Nuclear Material	159 states parties		Protection of nuclear material in facilities, in storage and during transport in order to secure it against diversion. Accompanied

⁵ This includes measures to prevention proliferation to non-nuclear weapons states and diversion to non-state actors.

				by efforts to detect and respond to any illicit attempts to access such materials.
Non-proliferation	2005 International Convention for the Suppression of Acts of Nuclear Terrorism	116 states parties		Commits states to various measures to prevent nuclear terrorism, including criminalisation.
Non-proliferation	Nuclear Suppliers Group	48 states, including the five original nuclear powers		Coordination on proliferation while facilitating trade for peaceful uses, including through two sets of guidelines.
Non-proliferation	Guidelines for Nuclear Transfer			Includes a 'trigger list'. Items on this list should only be supplied: if assurances are received that they are not for use in a nuclear device; with appropriate physical protection; and to a recipient country that has an agreement on safeguards in place with IAEA.
Non-proliferation	Guidelines for transfers of nuclear-related dual-use equipment, materials, software, and related technology			Items listed in its annex should not be transferred where there is a risk of proliferation, diversion to nuclear terrorism, or use in a nuclear explosive device.
Non-proliferation	The Wassenaar Arrangement (Final Declaration, Guidelines and Procedures: Initial Elements)	42 states		Promotion of transparency and responsibility in transfers of arms and dual use items.
Non-proliferation	The Missile Technology Control Regime (MTCR)	35 states		Coordination of export licensing for unmanned delivery systems that could be used to deliver weapons of mass destruction (WMD).
Non-proliferation	MTCR Guidelines for Sensitive Missile Relevant Transfers			Controlling transfer of items that could be used in WMD delivery systems.
Non-proliferation	Equipment Software and Technology Annex			Includes a list of category I and category II items; those in category one require greater level of control.
Non-proliferation	The Hague Code of Conduct Against Ballistic Missile Proliferation	A voluntary arrangement with 140 subscribing states		Transparency and confidence building around the proliferation of ballistic missiles that could be used to carry WMDs including annual policy declarations and pre-launch notifications on ballistic missile and space-launch vehicle launches (SLVs) and test flights.
Non-proliferation	International Atomic Energy Agency (IAEA)	171 member states		Promotes scientific and technical cooperation for peaceful uses of nuclear technology; has general responsibility for nuclear safety and security; and concludes safeguard agreements with states in connection with their responsibilities under the NPT and / or as part of nuclear weapons free zones.

Non-proliferation	IAEA Safeguards	182 states were applying safeguards in 2018		Sets of technical measures that enable IAEA verification of application of nuclear technology solely for peaceful purposes.
Nuclear safety and security	IAEA International Network for Nuclear Security Training and Support	Membership open to all IAEA member states		Supports cooperation, information sharing and development of good practice among national Nuclear Security Support Centres.
Nuclear safety and security	IAEA International Nuclear Security Education Network	Informal membership open to group involved in nuclear security education, and to observership by relevant international organizations and NGOs.		Partnership of the IAEA and educational and research institutions to develop, deliver and evaluate nuclear security education.
Geographic limitation ⁶	1959 Antarctic Treaty	54 states parties		Antarctica may only be used for peaceful purposes and nuclear explosions and disposal of radioactive waste are prohibited.
Geographic limitation	1967 Outer Space Treaty	109 states parties		Prohibits nuclear weapons and other WMDs being placed in orbit; or installed on moon or other celestial bodies; and contains a broader ban on military activities / development in outer space.
Geographic limitation	1967 Latin America Nuclear Weapons Free Zone Treaty (Treaty of Tlatelolco)	33 states parties		The prohibition and prevention of the testing, use, production, and manufacture of nuclear weapons, and of their receipt, storage, installation, or deployment.
Geographic limitation	Additional Protocol I to the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean	4 states parties (France, the Netherlands, UK and US)		Commitment to respect the statute of denuclearization from the Treaty, in territories in the geographical zone for which they have international responsibility.
Geographic limitation	Additional Protocol II to the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean	5 states parties (China, France, Russia, UK and US)	4 with reservations	Commitment to: respect the statute of denuclearization; not to contribute to prohibited activities; and not to use or threaten to use nuclear weapons against its member states of the nuclear weapons free zone.
Geographic limitation	1971 Seabed Treaty	94 states parties		States commit not to place on the seabed: nuclear weapons or any other types of weapons of mass destruction; and any structures, launching installations or any other facilities specifically designed for storing, testing or using such weapons.
Geographic limitation	1985 South Pacific Nuclear Free Zone Treaty (Treaty of Rarotonga)	13 states parties		Parties agree not to: manufacture, acquire, possess, or control, nuclear explosive devices; proliferate fissionable material except for peaceful purposes under NPT/IAEA safeguards; allow stationing or testing of nuclear explosive devices on their territory; dump radioactive waste or other radioactive matter within the zone.

⁶ Limitation of activities involving nuclear weapons, nuclear explosive devices, related installations and radioactive waste, generally by prohibiting these in a set area or 'zone'.

Geographic limitation	Protocol I (to the Treaty of Rarotonga)	2 states parties (UK and US)		States commit to apply the prohibitions from Articles 3, 5 and 6 of the Treaty to territories for which they are internationally responsible within the zone.
Geographic limitation	Protocol II (to the Treaty of Rarotonga)	4 states parties (China, France, Russia and the UK)	The US is also eligible to be a party, but has not yet ratified the Protocol.	States agree not to use or threaten to use nuclear explosive device against parties to Treaty or territories in the zone for which they have international responsibility.
Geographic limitation	Protocol III (to the Treaty of Rarotonga)	4 states parties (China, France, Russia and the UK)	The US is also eligible to be a party, but has not yet ratified the Protocol.	States agree not to test nuclear explosive devices in the zone.
Geographic limitation	1996 African Nuclear Weapon Free Zone Treaty (Treaty of Pelindaba)	40 states parties		States agree not to: research, develop, manufacture, stockpile, acquire, possess, or have control over a nuclear explosive device; encourage such action by others; station or test any nuclear explosive device; dump radioactive waste or any other radioactive matter in the zone; or make, assist or encourage an armed attack against any nuclear installation. They also committed to destroying any existing nuclear explosive device.
Geographic limitation	Protocol I (to the Treaty of Pelindaba)	4 states parties (China, France, Russia and the UK)	The US is also eligible to be a party, but has not yet ratified the Protocol.	States agree not to use or threaten to use nuclear explosive device against parties to Treaty, or territories in the zone for which they have international responsibility.
Geographic limitation	Protocol II (to the Treaty of Pelindaba)	4 states parties (China, France, Russia and the UK)	The US is also eligible to be a party, but has not yet ratified the Protocol.	States agree not to test nuclear explosive devices in the zone.
Geographic limitation	Protocol III (to the Treaty of Pelindaba)	1 (France)	Spain is also eligible to be a party, but has neither signed nor ratified the Protocol.	Commits to applying the provisions from Articles 3-10 of the treaty to territories for which they are internationally responsible within the zone.
Geographic limitation	1995 Treaty on the Southeast Asia Nuclear-Weapon Free Zone	10 states parties		States parties commit not to: develop, manufacture, acquire, possess, have control over, station, transport, test or use nuclear weapons; allow another state to do any of those acts on their territory; or discharge radioactive material or waste into the sea or atmosphere or territory of another state.
Geographic limitation	Protocol to the Treaty on the Southeast Asia Nuclear-Weapon Free Zone	0 states parties	China, France, Russia, the UK and US are eligible to become parties	States agree not to use or threaten to use nuclear weapons against states parties to the Treaty or within the zone, and not to otherwise violate the treaty.
Geographic limitation	2006 Treaty on a Nuclear-Weapon-Free Zone in Central Asia	5 states parties		States parties commit not to: research, develop, manufacture, stockpile, acquire, possess, test, or have control over any nuclear weapon or nuclear explosive device; not to seek, receive, or give assistance for such acts; allow in their territory, production, acquisition, stationing, storage, use, receipt, stockpiling, installation, or possession of any nuclear weapon

				or nuclear explosive device; or allow disposal of radioactive waste by other states in its territory.
Geographic limitation	Protocol to the Treaty on a Nuclear-Weapon-Free Zone in Central Asia	4 states parties (China, France, Russia and the UK)	The US is also eligible to be a party, but has not yet ratified the Protocol.	States agree not to use or threaten to use a nuclear weapon or nuclear explosive device against states parties to the Treaty or in the zone and not to contribute to any violation of the Treaty.
Limits on testing ⁷	1963 Limited Test Ban Treaty (also known as the Partial Test Ban Treaty)	126 states parties	Superseded by the Comprehensive Test Ban Treaty in 1996	Bans nuclear tests in the atmosphere, outer space, and underwater. Also bans tests in the environment where radioactive debris would not be restricted to the territory of the responsible state.
Limits on testing	1974 Threshold Test Ban Treaty	United States and Soviet Union		Bans tests above 150 kilotons.
Limits on testing	1976 Peaceful Nuclear Explosions Treaty	United States and Soviet Union		Applies to nuclear explosions outside the test sites of the Threshold Test Ban Treaty, also limiting these to below 150 kilotons.
Limits on testing	1996 Comprehensive Test Ban Treaty (CTBT)	168 states parties	Not yet in force. Requires ratification by 8 additional states (China, Democratic People's Republic of Korea, Egypt, India, Iran, Israel, Pakistan, and the United States of America).	States agree: not to carry out any nuclear weapons test explosion or any other nuclear explosion; and to prohibit and prevent any such explosion within their jurisdiction / control. There will be inspection capabilities once the Treaty enters into force (requiring request and approval by member states).
Limits on testing	Preparatory Commission for the Comprehensive Test Ban Treaty Organization	184 member states	Once the CTBT enters into force the Comprehensive Test Ban Treaty Organization (CTBTO) will be formed.	Conducts preparatory activities for entry into force of the CTBT, including those detailed below.
Limits on testing	International Monitoring System		Will include 337 facilities once complete; currently about 90% are functional.	Global network of monitoring facilities detecting seismic activity, soundwaves (underwater and surface), and radioactive particles in the atmosphere, from which nuclear testing can be detected.
Limits on testing	International Data Centre			Receives, processes and distributes data from monitoring stations to member states.
Limits on testing	Provisional Technical Secretariat for the CTBTO			Assists the Preparatory Commission in setting up the global monitoring system.
Limits on testing	International Association of Seismology and Physics of the Earth's Interior (IASPEI)	IASPEI has 70 national representative members (in non-governmental capacity)		Contributes to verification and detection activities that support the work of the CTBT International Monitoring System.

	Commission on Seismological Observation and Interpretation			
Confidence building ⁸	1963 Hotline Agreement	United States and Soviet Union		Established a direct communications link between governments to help avert nuclear crises.
Confidence building	1988 Ballistic Missile Launch Notification Agreement	United States and Soviet Union		Agreement to provide notification at least 24 hours in advance of the planned date, launch area and area of impact of any strategic ballistic missile launches.
Confidence building	1992 Open Skies Treaty	34 states parties		Sets out arrangements for observation flights by states parties over the territories of other states parties. These are made subject to quotas and limited to certain types of sensors.
Confidence building	Other hotline arrangements	Bilateral		Several other hotline arrangements – generally between nuclear weapons states – have been created to improve communication in times of crisis.
Mitigation and response ⁹	1986 Convention on Early Notification of a Nuclear Accident	120 states parties plus four international organizations (EURATOM; World Health Organization; Food and Agriculture Organization; and World Meteorological Organization). A Convention of the IAEA.		A system for notification of nuclear accidents which have the potential for release of radioactive material across international borders. IAEA must be notified, as well as the affected state(s).
Mitigation and response	1986 Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	115 states parties plus four international organizations (EURATOM; World Health Organization; Food and Agriculture Organization; and World Meteorological Organization). A Convention of the IAEA.		Provides a framework for international cooperation in response to nuclear accidents and radiological emergencies. IAEA notified of expertise and assistance that states parties are capable of making available.
Mitigation and response	IAEA Response and Assistance Network			Route through which states parties to the Convention on Assistance can register their capabilities.
Mitigation and response	Food and Agriculture Organization – Emergencies Nuclear Release and Radioactivity; and Nuclear Emergencies Crisis Network of Technical Experts	The network draws on expertise from across the Organization.		Provides assistance around contamination of food and agricultural environments.

⁸ Measures that help maintain constructive relationships between states and avoid misinterpretation of incidents that could lead to use of nuclear weapons.

⁹ As mentioned in the report, arrangements for response to nuclear and radiological accidents while generally not addressing the outcomes of a nuclear attack, may form the basis for response activities which are not covered elsewhere.

Mitigation and response	IAEA Incident and Emergency Centre			Provides the hub for international preparedness and response to nuclear and radiological accidents and emergencies, including where these are the result of deliberate acts. Also advises on communication with the public during such incidents.
Mitigation and response	IAEA International Emergency Preparedness and Response Framework			Provides a framework for building capabilities for preparedness and response to nuclear and radiological emergencies.
Mitigation and response	Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE)			A coordination mechanism between international agencies for preparedness and response to nuclear and radiological emergencies. It oversees the operation of the Joint Radiation Emergency Management Plan.
Mitigation and response	2017 Joint Radiation Emergency Management Plan of the International Organizations	20 international or regional agencies and organizations ¹⁰		Provides the framework for the contributions of the participating international and regional agencies and organizations in preparedness and response for nuclear and radiological emergencies.
Mitigation and response	IACRNE Working Group on Coordinated International Exercises			Supports nuclear and radiological emergency exercises of individual organizations and collaborative exercises among organizations.
Mitigation and response	IACRNE Ad-Hoc Working Group on Air and Maritime Transportation			Facilitates coordination between relevant international agencies and organizations for preparedness and response to impacts of nuclear or radiological emergencies on international air and maritime transportation.
Mitigation and response	2005 IAEA/WHO Generic Procedures for Medical Response During a Nuclear or Radiological Emergency			Provides procedures and guidance for medical personnel to apply during response to nuclear and radiological emergencies.
Mitigation and response	International Health Regulations (2005)	193 states parties		Notification requirements for potential 'public health emergencies of international concern' and some core capacity building requirements may apply to nuclear and radiological emergencies.

¹⁰ Including: the IAEA; CTBTO Preparatory Commission; Euro-Atlantic Disaster Response Coordination Centre; European Atomic Energy Community (EURATOM); European Commission; the European Union Agency for Law Enforcement Cooperation (EUROPOL); FAO; International Civil Aviation Organization; International Labour Organization; International Maritime Organization; INTERPOL; the OECD Nuclear Energy Agency; Pan-American Health Organization; UN Development Programme; UN Environment Programme; UN Office for the Coordination of Humanitarian affairs; UN Office on Outer Space Affairs; World Health Organization; World Meteorological Organization; International Federation of Red Cross and Red Crescent Societies; and UN Scientific Committee on the Effects of Atomic Radiation.

Mitigation and response	WHO Radiation Emergency Medical Preparedness and Assistance Network	Over forty members among medical, public health and research institutions with specialisms relating to management of radiation emergencies.		Enables sharing of experience, information and good practice among participating institutions, and with countries who otherwise lack access to relevant technical expertise. Its emergency management work is activated when the IAEA or WHO are notified of a radiation accident.
Mitigation and response	IAEA Safety Standards Series - General Safety Requirements: Preparedness and Response for a Nuclear or Radiological Emergency	Jointly sponsored by IAEA and 12 other organizations and agencies from IACRNE.		Provides guidance for establishing adequate levels of preparedness and response arrangements at local and national levels. It is aimed at governments, and other agencies and organizations with emergency management responsibilities.
Mitigation and response	UN Scientific Committee on the Effects of Atomic Radiation	27 designated countries provide scientists as members of the committee.		Works to provide scientific information on the effects of ionizing radiation in support of protection efforts.

Super-Volcanic Eruptions

INSTRUMENT / ORGANIZATION	PARTICIPATION	STATUS	MANDATE / SCOPE
World Meteorological Organization	187 member states	Inter-governmental	Information and advice on weather and climate hazards associated volcanic eruptions, using its atmospheric observation and modelling capabilities.
UNESCO Intergovernmental Oceanographic Commission	150 member states	Inter-governmental	Promotes international collaboration and coordination of global ocean science research; includes a Tsunami Programme with research focusing on protection of lives and livelihoods.
International Tsunami Information Centre		Inter-governmental	Provides general support, outreach and training to countries that may be affected by tsunami events and real-time support during such events on request.
Four tsunami warning systems	Each system has around 30-40 participants.	Inter-governmental	Covering the Pacific, Caribbean, Indian Ocean, and North East Atlantic and Mediterranean.
International Monitoring System of the Comprehensive Test Ban Treaty Organization	Will include 337 facilities once complete; currently about 90% are functional.	Inter-governmental	Some of the facilities in this system undertake seismic monitoring which could help identify and monitor seismic unrest around volcanic sites.
Volcanic Ash Advisory Centres	9 advisory centres	Multilateral expert community	The centres monitor volcanic ash plumes within their assigned airspace and provide advice for aviation.
Smithsonian Institution Global Volcanism Program		Multilateral expert community	Conducts research to advance understanding of volcanic activity globally and makes resulting information available to others.

US Geological Survey Volcano Hazard Program		Multilateral expert community	Undertakes monitoring, research and hazard assessment on active volcanoes.
US Geological Survey Volcano Disaster Assistance Program	Approximately 20 geologists, geophysicists, and engineers.	Multilateral expert community	Provides teams for on-the-ground assistance during volcanic eruption events, and supports training, and development of monitoring and mitigation technologies.
International Union for Geodesy and Geophysics	59 regular and 13 associate national members participating in a non-governmental capacity	Multilateral expert community	An international scientific union focused on studies of the Earth, and its application for the benefit of humanity, including through reducing the impacts of natural hazards.
International Association for Volcanology and Chemistry of the Earth's Interior	Currently 52 national members (participating in a non-governmental capacity) and over 400 individual members.	Multilateral expert community	Provides a central focal point for international research activities in volcanology and related disciplines, including research on mitigation of volcanic disasters.
Joint Tsunami Commission	A collaborative effort between the IUGG International Association for the Physical Sciences of the Oceans; International Association on Seismology and Physics of the Earth's Interior; and International Association of Volcanology and Chemistry of the Earth's Interior.	Multilateral expert community	Brings together researchers from across IUGG to advance understanding of tsunami hazards and their consequences.
International Volcanic Health Hazards Network	Individual academics and practitioners with expertise in health impacts of volcanic eruption events.	Multilateral expert community	Brings together experts from a variety of disciplines to advance understanding of the health impacts of volcanic eruptions and of associated protection measures.
World Organization of Volcano Observatories	80 observatories in 33 countries / regions	Multilateral expert community	A commission of the IAVCEI which brings together institutions involved in volcano surveillance.
WOVO-Dat	Over 70 observatories have contributed data.	Multilateral expert community	Working to address gaps in global data on volcanic activity, through creation of a centralized database. This should support research on volcanic unrest and particularly the sorts of patterns that might occur pre-eruption.

9. Appendix II: Acronyms and Abbreviations

Nuclear Warfare	
CTBT(O)	Comprehensive Test Ban Treaty (Organization)
FAO	Food and Agriculture Organization
EURATOM	European Atomic Energy Community
IACRNE	Inter-Agency Committee on Radiological and Nuclear Emergencies
IAEA	International Atomic Energy Agency
IASPEI	International Association of Seismology and Physics of the Earth's Interior
ICANW	International Campaign for the Abolition of Nuclear Weapons
ICJ	International Court of Justice
MTCR	Missile Technology Control regime
NewSTART	New Strategic Arms Reduction Treaty
NPT	Non-Proliferation Treaty
START	Strategic Arms Reduction Treaty
UNGA	United Nations General Assembly
UNIDIR	United Nations Institute for Disarmament Research
UNODA	United Nations Office of Disarmament Affairs
UNOOSA	United Nations Office of Outer Space Affairs
UNSC	United Nations Security Council
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WMD	Weapon of mass destruction
WHO	World Health Organization
Super-volcanic Eruption	
CTBTO	Comprehensive Test Ban Treaty Organization
IAVCEI	International Association of Volcanology and Chemistry of the Earth's Interior
ITIC	International Tsunami Information Centre
IUGG	International Union of Geodesy and Geophysics
IVHHN	International Volcanic Health Hazards Network
UNESCO	United Nations Educational Scientific and Cultural Organization
UNESCO-IOC	UNESCO-International Oceanographic Commission
WMO	World Meteorological Organization
WOVO	World Organization of Volcanic Observatories

Unknown Risks	
UNSCEB	United Nations Chief Executives Board for Coordination
Asteroid Impacts	
COPUOS	Committee on Peaceful Uses of Outer Space
IAU	International Astronomical Union
IAWN	International Asteroid Warning Network
JPL-NEO	Jet Propulsion Laboratory - Center for Near-Earth Object Studies
MPC	Minor Planet Center
NASA	National Aeronautics and Space Administration
NEO	Near-Earth object
UNOOSA	United Nations Office of Outer Space Affairs
Pandemics, Biological and Chemical Warfare	
BTWC	Biological and Toxin Weapons Convention
CWC	Chemical Weapons Convention
EMPRES	Emergency Prevention System
FAO	Food and Agriculture Organization
GISRS	Global Influenza Surveillance and Response System
GLEWS	Global Early Warning System
GOARN	Global Outbreak Alert and Response System
IHR	International Health Regulations
ISU	Implementation Support Unit
OIE	World Animal Health Organization (previously the Office International des Epizooties)
OPCW	Organization for the Prohibition of Chemical Weapons
WAHID/WAHIS	World Animal Health Information Database / World Animal Health Information System
WHA	World Health Assembly
WHO	World Health Organization
Climate Change	
GEF	Global Environment Facility
EBRD	European Bank of Reconstruction and Development
MEF	Major Economies Forum
IPCC	Intergovernmental Panel on Climate Change
UNEP	United Nations Environment Programme
ICAO	International Civil Aviation Authority
IMO	International Maritime Organisation

SDG	Sustainable Development Goal(s)
UNFCCC	United Nations Framework Convention on Climate Change
PIK	Potsdam Institute for Climate Impact Research
NAZCA	Non-State Actor Zone for Climate Action
AI	
HLMI	High-Level Machine Intelligence
LAWs	Lethal Autonomous Weapons
SCO	Shanghai Cooperation Organisation
ITU	International Telecommunications Union
Solar Geoengineering	
CBD	Convention on Biological Diversity
ENMOD	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
ICJ	International Court of Justice
LRTAP	Convention on Long-Range Transboundary Air Pollution