Existential Risk and Global Catastrophic Risk: A Review

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Terms of Reference

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Contents

1. Introduction

Global catastrophic and existential risks are often considered as either events that may directly cause the extinction or demise of humanity (e.g. asteroid impact), or those that may begin a chain reaction of impacts that cascade humanity towards unrecoverable collapse (e.g. nuclear war that causes sunlight blocking scenarios with disruption to global food production). Both existential and global catastrophic risks are garnering greater attention in national and international risk forums, spurred on by the COVID-19 pandemic and the Russia-Ukraine war, and in advancing recognition of the complex systemic nature of risk. Indeed, a 2023 report from the United Nations Office for Disaster Risk Reduction (UNDRR) suggests that there is a need for greater understanding of the extreme risk scenarios that constitute global catastrophic risks in order to “drive better responses and preparedness for both known and potential unknown future events and improve the modelling of major systemic risks and cascades” (Stauffer et al., 2023). In the US the importance of the field has been further cemented by the passing of the Global Catastrophic Risk Management Act in 2022, which identifies that any global catastrophic risks that have “consequences severe enough to result in systemic failure or destruction of critical infrastructure or significant harm to human civilization” must be assessed and accounted for in national disaster management planning (Global Catastrophic Risk Management Act, 2022).

The term ‘existential risk’ represents both a category of risks considered to lead to the unrecoverable collapse or extinction of humanity, and the encompassing field of study, although the latter is also sometimes referred to as Existential Risk Studies (ERS). Existential risk as a term was first coined by Nick Bostrom – a Professor of Philosophy at the University of Oxford (formerly within the now-shuttered Future of Humanity Institute) – and is still the subject of much debate in terms of solidifying a clear definition for the term (which will be touched on later in this report) and, indeed, which hazards may constitute such a risk, and associated quantitative thresholds. Some risks that are commonly thought of as falling into this category may include nuclear war, asteroid impacts, climate change, pandemics, and emerging technologies such as 'uncontrollable' or 'unaligned' artificial intelligence. Existential risk is a special case within the category ‘global catastrophic risk’ – potential events from which human society may recover, but may drastically change trajectory or lead to a loss of at least 10% of global population and up to as much as 25% (Cotton-Barratt et al., 2016; Kemp et al., 2022). In this framework, therefore existential risks are global, catastrophic, and harmful enough to count as extreme global catastrophic risks, but conversely, not all global catastrophic risks are so extreme that they qualify as existential risks. In this reading, existential risks are a subset of GCRs. Importantly, both terms can be distinguished from catastrophic risk and most hazard-induced disasters, which are inherently smaller in scale.

This report aims to provide a brief overview of global catastrophic and existential risk. The first section identifies how the field of Existential Risk Studies has developed over time, whilst presenting recent work to define and classify global catastrophic risk and existential risk (including thresholds for categorization of risk). The report then identifies how these risks are currently managed and governed and aims to inform the identification of the scope of hazards with potential catastrophic and existential impacts to be considered within the context of the UNDRR.

1.1. A brief history of Existential Risk Studies

An account by Beard and Torres (Beard & Torres, 2020) of the history of Existential Risk Studies (ERS) distinguishes three waves of development within the field which, though not mutually exclusive nor even wholly separable, can be characterised by how they define key terms, underpinning values, how they use classification, and what methods they employ. According to this view, early forbears of ERS emerged from science fiction and – importantly for the establishment of a *scholarly* field – from 'concerned scientists' who, largely, pointed to advances in science and technology as having potentially vast and catastrophic consequences for humanity. Canonical 'concerned scientists' were those working on nuclear physics in the early part of the twentieth century leading up to the development of the atomic bomb who expressed great discomfort about the applications of their work. Examples include Oppenheimer, Szilard and Einstein (Beard & Bronson, 2023).

Topics of concern naturally included nuclear weapons, but increasingly, worry about environmental catastrophe (Carson et al., 2000) population explosions, nanotechnology, biological weapons, and high energy physics experiments (Dar et al., 1999) came to the fore as well. This view of existential risk draws out ways in which the 21st century, building on then-recent technological developments, had seen the risk of human calamity accelerated, typified in Lord Martin Rees's 2004 book *Our Final Century: Will the Human Race Survive the Twenty-First Century?* (Rees, 2004). In general, these 'concerned scientists' tended to take a hazard-centric approach to ERS, often starting with discrete events and drawing out scenarios stemming from these. An example of this might be a "simple causal chain from nuclear conflict to firestorms to stratospheric soot to famine" (Beard & Torres, 2020). Their aim appears to have been broadly to raise awareness of these risks, both among policymakers and the general public (hence the largely 'popular' nature of the resultant books and publications) rather than in academic research looking at specific pathways or probabilities. Examples of this 'scientific activism' include the establishment of the influential *Bulletin of Atomic Scientists* (which, to this day, yearly updates its metaphorical "Doomsday Clock" of how close we are to the end of humanity) and the Union of Concerned Scientists.

Much of the early work in ERS was grounded in philosophy and was proposed as a unified academic field of study by Nick Bostrom. In his seminal paper *Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards*, he proposed a holistic view of existential risks and their impacts on the continued development in flourishing of humanity (Bostrom, 2002). In later works, Bostrom proposed two categories of extreme risks - Global Catastrophic Risk and Existential Risk. **Figure 1** is taken from this paper and shows how he began to characterise these risks, providing basic thresholds for their classification. These works by Bostrom form part of Beard and Torres' second wave of ERS, which, drawn from philosophy, makes use of normative frameworks such as utilitarianism and transhumanism (Beard & Torres, 2020). The latter is particularly implicated in Bostrom's inclusion of ageing as a global catastrophic risk. This is a perhaps controversial notion, and indeed scholars such as Jebari have argued that longevity research programmes themselves might intensify catastrophic risks (Jebari, 2014), but its inclusion points to the philosophical traditions that are implicated in this way of thinking about existential risk.

Since the early 2000's ERS has continued to grow and evolve, fuelled by the establishment of two research Centres dedicated to this purpose: the (now-shuttered) Future of Humanity Institute (FHI) at the University of Oxford (2005) and the Centre for the Study of Existential Risk (CSER) at the University of Cambridge (2011), where the authors of this report are based,

as well as organisations such as the Global Catastrophic Risk Institute (2011), the Global Challenges Foundation (2012), and the Future of Life Institute (2014). The growth of ERS in this second wave is also characterised by the parallel growth in popularity of movements such as Effective Altruism, collapse studies, and longtermism — a philosophical approach that focuses on maximising total human wellbeing by improving the prospects of the far-future[1].

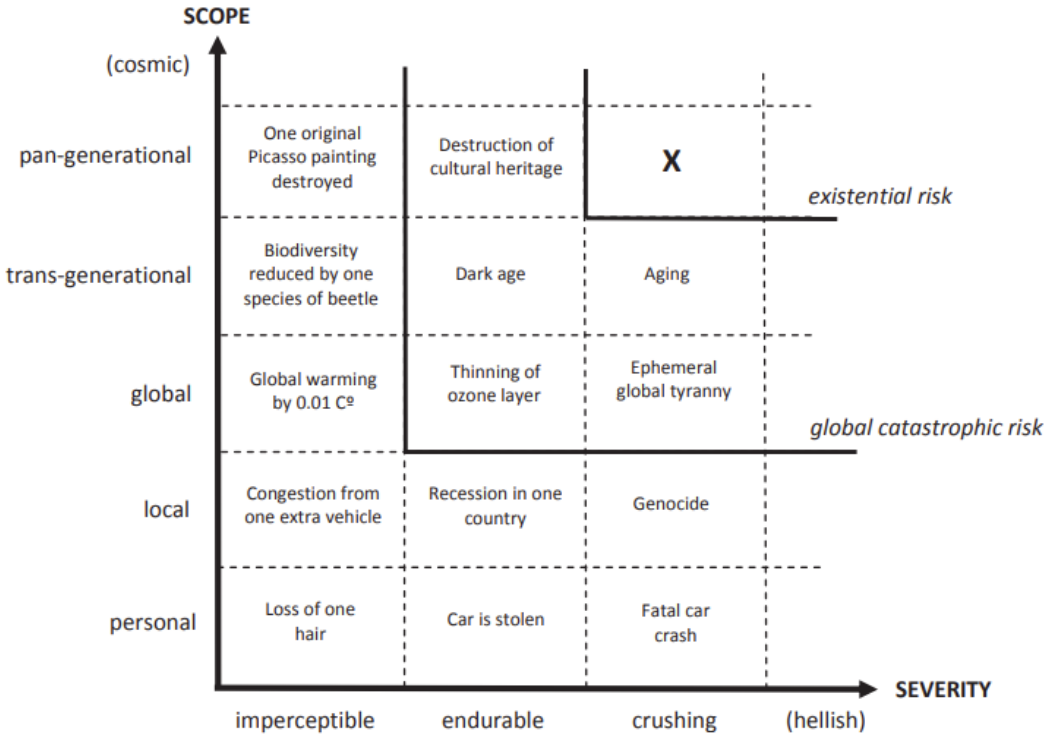

Figure 1. *Taken from Bostrom (2013), this simplified depiction of the crude categorisation of existential and global catastrophic risks, based on scale (personal, local or global, trans-generational or pan-generational), and the severity of this risk (imperceptible, endurable, crushing or hellish). Existential risks represent the highest order of both spectrums, whilst global catastrophic risks are one to two orders of severity or scope below existential risk.*

This *third wave* of development proposed by Beard and Torres (2020) of ERS sees input from a far greater range of disciplines beyond philosophy and is thus characterised by an interdisciplinary and systemic approach. This sees existential and global catastrophic risks less as causal chains from trigger to calamity and more as characteristics of complex and highly-networked systems. Thus, research in this wave pays greater attention than earlier waves to exploring multi-factor risk cascades, noting particularly the importance of science governance, 'signposts' on the way to catastrophe, and critical vulnerabilities. The interdisciplinarity means that it is difficult to enumerate an overall methodological approach but common methods of studying these are horizon-scanning, expert elicitation and multi-stakeholder scenario development, as well as systemic risk assessment.

1.2. Scope, Growth and Composition of the Field

Estimating the growth and breadth of the field as would customarily be done through bibliometric analysis is a difficult task here for a number of reasons: First, the coinage and use of the terms "existential risk" and "global catastrophic risk" is relatively recent, and there are

[1] The relationship between existential risk and the adjacent field of longtermism is explained further in popular texts such as *What we Owe the Future* (MacAskill, 2022).

few, if any, academic journals dedicated to the field (the closest are journals dealing with Futures Studies). The terms are also common in general parlance and often crop up in irrelevant publications (for example “existential risks” to a particular industry). Specifying the scope as considering risks to humanity as a whole then includes vast theological/apocalyptic literature which is quite separate from what we are concerned with here. Moreover, notably (though anecdotally) much of the output from these fields is in grey or white literature, or even in informally-circulated Google Documents or shared on online forums such as Effective Altruism Forum and thus would be missed in standard systematic review searches. As with bibliometric analysis, understanding the composition of the field in terms of the numbers, specialisms and geographic locations of its practitioners is also difficult, for similar reasons. Very few institutions (within or outside academia) explicitly use the terms “existential risk” or “global catastrophic risk”. Research in this domain is also conducted through think tanks and research centres working across themes of civilisation collapse and longtermism which can encompass themes of global catastrophic and existential risk, and often remain unattributed.

Nevertheless, a crude analysis of the existing English-language academic literature follows. Searches for both “existential risk” and “global catastrophic risk” were conducted using the Web of Science and Scopus databases (**Table 1**). The results from the Scopus searches yielded more results in both searches and the results are plotted below in **Figure 2.a** to illustrate the growth in the fields’ publication outputs over time and shows a drastic increase in publications from around 2010 onwards. Much of the recent literature has been published by authors in the US and UK, accounting for 64.8% of the published literature, with a further 38.8% of publications from other European countries (**Figure 2.b**). Few publications originate from South America (3.4%), Southern and Southeast Asia (3.6%) and Africa (1.1%). A more detailed breakdown of these search results, including a discipline breakdown is presented in **Appendix A.**

Database	Number of documents	
	Existential Risk	**Global Catastrophic Risk**
Scopus	455	131
Web of Science	244	76

Table 1. *The number of articles found by each database when searching for the terms ‘existential risk’ and ‘global catastrophic risk’ up until 2024.*

Alongside traditional academic institutions, there are also, of course, individual researchers and research groups whose work is highly relevant to existential and catastrophic risks, as well as specific areas of focus within policy institutions, along with research focused on specific risk areas. There have been attempts to connect these experts in initiatives such as the Centre for the Study of Existential Risk and the Simon Institute for Longterm Governance’s Global Catastrophic Risk Science-Policy Interface (Rios Rojas et al., n.d.). This network sought to bring together experts from policy and academia with an interest in existential and catastrophic risk. More recently, organisations have developed in the field to try and increase diversity and inclusivity, such as *Riesgos Catastróficos Globales*, a think tank looking particularly at Latin American perspectives. A summary of the main organisation and institutions working within the field are included in **Appendix B.** To-date, there are no institutions explicitly focused on global catastrophic or existential risk across Asia or Africa, leaving a gap in current perspectives in the field.

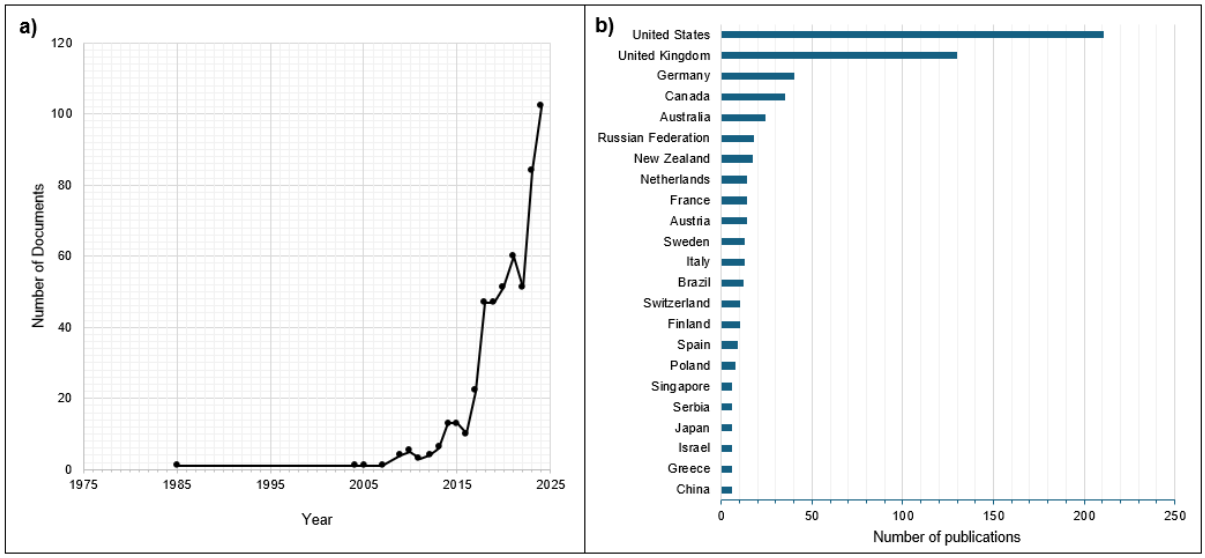

Figure 2. *Graphs using data drawn from SCOPUS to show the a) number of publications covering global catastrophic or existential risk per year and, b) the number of publications by country until 2024.*

1.3. Specific risk areas

Taking as reference points the institutions noted above as expressly devoted to the study of existential risk, there are a number of risk areas that emerge as particularly prevalent. These include: Risks from Artificial Intelligence; Biological and Biotechnological Risk; Natural Risk including volcanic eruptions, asteroid impacts and space weather; Nuclear Risks; Climate/Biodiversity Risks; and Global Justice. Alongside, though less frequently with dedicated programmes (the Cascade Institute's Polycrisis Project being one such), are projects that examine pathways, complexity and risk networks, covering systemic risk and the polycrisis. The field also includes research programmes (such as CSER's A Science of Global Risk) that make reflexive attempts to support the field's establishment as a rigorous discipline by examining and developing 'foundational tools' including specific methodologies, policy-pathways to impact and communication tools (Sundaram et al., 2023).

Within the Global Catastrophic Risk Management Act passed in the US in 2022, it states "examples of global catastrophic and existential threats include severe global pandemics, nuclear war, asteroid and comet impacts, supervolcanoes, sudden and severe changes to the climate, and intentional or accidental threats arising from the use and development of emerging technologies." (Global Catastrophic Risk Management Act, 2022) although the criteria for selecting these hazards remains unclear.

A recent effort to bibliometrically analyse the state of the field's academic output used bibliographic coupling (which defines papers as similar when they have similar reference lists) to identify distinct research clusters (Jehn et al., 2024) in papers that explicitly situate themselves within existential risk. The identified clusters were: "Foundations" (key foundational texts of the field), "Artificial Intelligence", "Climate Change", "Governance", "Pandemics", "Transhumanism", "Global Resilience and Food Security", "Risk Management and Mitigation", "Reasoning and Risk", and "Emerging Biotechnologies, Emerging Futures".

Applied to existential risk, the scope of risk themes narrows. In a 2025 study by ÓhÉigeartaigh, existential risks were categorised into exogenous and endogenous based on their links to human activity. The author suggests that for exogenous risks, encompassing volcanic activity,

space weather, asteroid impact the existential risk potential is low. However, for endogenous risks including climate change and environmental degradation, biological agents, nuclear war, artificial intelligence, and unknown future technological developments, there is a stronger uncertainty of their potential as existential threats, suggesting that they warrant progress towards prevention and mitigation (ÓhÉigeartaigh, 2025).

2. What are global catastrophic and existential risks?

Both the terms 'existential risk' and 'global catastrophic risk' are used to identify high-impact risk scenarios that may have severe consequences for humanity. However, debate continues within the field of ERS to provide discrete definitions for both categories of risk. Here, we present recent authorship seeking to provide clarity on these definitions, and distil this into working definitions for the purpose of this review. These definitions are largely concerned with the 'end-state' (number of fatalities, or prospects for human flourishing, for example) and not with the *pathways* that would contribute to these end-states. We discuss the latter in subsequent sections of this review. It is important to note that several definitions exist and none are settled nor universally adopted. However, what emerges from the literature is a 'common-sense understanding' of scale and scope for both existential and global catastrophic risks.

2.1 Definitions: Existential Risk

One of the earliest published definitions of the term 'existential risk' in the field comes from Nick Bostrom, who defines them as events "where an adverse outcome would either annihilate Earth-originating intelligent life or permanently and drastically curtail its potential. […] An existential risk is one where humankind as a whole is imperilled. Existential disasters have major adverse consequences for the course of human civilization for all time to come." (Bostrom, 2002). An alternative definition by the Future of Life Institute (FLI) proposes that "an existential risk is any risk that has the potential to eliminate all of humanity or, at the very least, kill large swaths of the global population, leaving the survivors without sufficient means to rebuild society to current standards of living." (Conn, 2015). A more recent definition is provided by Toby Ord, a philosopher at the University of Oxford) in his book *The Precipice: Existential Risk and the Future of Humanity* in which he defines an existential risk as "a risk that threatens the destruction of humanity's long term potential" (Ord, 2020). Ord also distinguishes between existential risk and existential catastrophe, suggesting an existential catastrophe as "the destruction of humanity's long-term potential".

For the purposes of this review, the following definition will be adopted: *Existential risks are the potential for hazards that, either directly or indirectly, could cause extinction of humanity or the irreversible collapse of society worldwide.*

2.2 Definitions: Global Catastrophic Risk

Similar to existential risk, 'global catastrophic risk' (GCR) is also lacking a settled definition, with different papers and institutes adopting different definitions, although largely, existential risks are considered a subset of global catastrophic risk. The phrase is first defined in the book *Global Catastrophic Risk* by Bostrom & Cirkovic, (2011) as: "a risk that might have the potential to inflict serious damage to human well-being on a global scale". They later go on to describe a global catastrophe as "a catastrophe that cause[s] 10 million fatalities or 10 trillion dollars of economic loss". Despite the relatively arbitrary nature of the figures used by Bostrom and Ćirković, this definition is the most widely used in the field, but over the last decade, attempts

have been made to sharpen it. In 2014, Baum & Handoh, (2014) defined global catastrophe as an event that exceeds the resilience of the global human system, resulting in a significant undesirable state change. This is a more meaningful definition, though it does not speak to long-term effects of such risks. In 2016, the Global Challenges Foundation (GCF), suggested that GCRs would encompass any events that led to the loss of at least 10% of global population (Cotton-Barratt et al., 2016) — again an arbitrary value, but one that has also been widely adopted within the field, even if only as a kind of 'shorthand' representing the scale and scope envisioned. Kemp et al., (2022) note the arbitrariness of this definition and propose their own as comprising the loss of at least 25% of the global population as well as "severe disruption of global critical systems (such as food) within a given timeframe (years or decades)." The authors note that their use of this higher-than-usual threshold is for the purposes of setting apart catastrophes that are historically unprecedented from those that have been experienced before[2]. These definitions are not (yet) widely adopted, however.

For the purpose of this study, the following definition will be adopted: *Global Catastrophic Risks (GCRs) as unusual events with global impacts that would be less severe than those of existential risks, and could result in the loss of at least 10% of the global population or the altering the future trajectory of humanity, but from which collapse is recoverable.*

2.2.1. Global Catastrophic Biological Risks

Perhaps the most developed definition in the realm of GCRs comes from the study of Global Catastrophic Biological Risks (GCBRs). The reasons for this are likely due to the relative maturity of theory and practice in the fields that GCBRs encompass, such as biosecurity, health security, global/public health, pandemic preparedness and the governance of the life sciences as emerging technologies. While the focus of GCBRs has largely been on human health (pandemics or human-affecting biological weapons, for example) these need not exclude threats to plants, or animals — if these also have a catastrophic outcome for humans, for example through cascading ecosystem collapse or through severe food-system disruptions.

One widely-accepted working definition is that GCBRs are: "those events in which biological agents—whether naturally emerging or reemerging, deliberately created and released, or laboratory engineered and escaped—could lead to sudden, extraordinary, widespread disaster beyond the collective capability of national and international governments and the private sector to control. If unchecked, GCBRs would lead to great suffering, loss of life, and sustained damage to national governments, international relationships, economies, societal stability, or global security." (Schoch-Spana et al., 2017). This definition, while more nuanced and precise than crude statements about "10% of global population" is nevertheless still biassed towards *suddenness*. There is not necessarily agreement, however, about whether global catastrophic risks (or even existential risks, for that matter) need be particularly sudden. Work within the CSER, for example, has looked at whether transmissible chronic diseases might, under certain circumstances, constitute Global Catastrophic Biological Risks.

3. Classifying existential and global catastrophic risks

[2] Kemp et al reserve the 10% threshold for risks of "global decimation" which, they argue, apart from being linguistically consistent, could plausibly be applied to historical moments that have been experienced before, such as the Black Death.

3.1 Definitional Classifications and Taxonomies

As we have seen, *definitions* of existential and global catastrophic risks often centre on the outcomes (although the definition of GCBRs does mention potential origins of different kinds of biological risk). Similarly, many attempts at classifications–especially those that stem from a philosophical tradition–also focus on the nature of the end-state. For example, Bostrom's paper that provides his definition (in Section 2.1) provides a classification of existential risks based on their potential outcomes, each of which points to the 'unsurvivability' (and thus 'existential' nature) of these risks:

- *Bangs* – Earth-originating intelligent life goes extinct in relatively sudden disaster [sic] resulting from either an accident or a deliberate act of destruction.
- *Crunches* – The potential of humankind to develop into posthumanity is permanently thwarted although human life continues in some form.
- *Shrieks* – Some form of posthumanity is attained but it is an extremely narrow band of what is possible and desirable.
- *Whimpers* – A posthuman civilization arises but evolves in a direction that leads gradually but irrevocably to either the complete disappearance of the things we value or to a state where those things are realized to only a minuscule degree of what could have been achieved.

(Bostrom, 2002)

A slightly different typology of existential risks is outlined by Torres (2019), whereby potential outcomes could include: (i) human extinction, (ii) human extinction or civilizational collapse, (iii) human extinction or a permanent and drastic loss of potential, (iv) any catastrophe with pan-generational-crushing effects, and a significant loss of expected value. According to Torres, each of these could run across a spectrum of scope and severity.

Both Torres and Bostrom's typologies, coming as they do from philosophy, class existential risks in terms of their impact on expected future value, considered as anything that humanity cares about or wants in this world (Cotton-Barratt & Ord, 2015). They are also largely concerned with the end-state, rather than the *path* to that end-state and, arguably, having a better understanding of that path can help us better identify the relevant potential hazards and combinations thereof.

3.2 Cause- and process-focused classifications and taxonomies

A second kind of risk taxonomy highlights, instead of the 'end-state', potential causes of such outcomes, or processes by which these outcomes might be reached. For the purposes of this review, these kinds of classifications are perhaps more informative than ones that deal purely with definitions, as they can help highlight those hazards and hazard-processes that are most likely to result in large-scale impacts: they can thus guide our efforts in research, understanding and, above all, prevention and mitigation.

Even when we try and draw out and then classify the causes and processes leading to global catastrophic risk (rather than existential risk which, by most definitions, can only happen once), we are faced with a paucity of data to help us on our way. Few global catastrophes in human history could be classified as GCRs under the definitions provided in Section 2. The Covid-19 pandemic with global deaths of 7 million (and even with upper estimates as much as 20 million deaths) falls far short of the predominantly used 10% threshold for GCRs. Even the 1918 Spanish influenza pandemic which, at its highest estimate is thought to have caused 100

million fatalities, would still only account for 5.4% of global population at the time (Johnson & Mueller, 2002). Events considered to have reached the GCR thresholds are the Black Death pandemic in the 14th Century (estimates of > 50% loss of global population) or, the much-contested Late Pleistocene 'population bottleneck' linked to the eruption of Mount Toba, Indonesia.

In his 2020 book *The Precipice,* philosopher Toby Ord sought to provide probability estimates for an 'existential catastrophe' over the next century. He presents an overall estimate of ~1 in 6 this century that humanity will experience an existential catastrophe, suggesting the most probable cause would be from unaligned artificial intelligence (~1 in 10), engineered pandemics (~1 in 30) or from 'unforeseen anthropogenic risks' (~1 in 30) (Ord, 2020). These probability estimates, although useful to provide a scale of severity and scope to aid classification of the risks, Ord notes have "significant uncertainties", and criticisms have highlighted that the estimates are "subjective probability estimates" that do not adequately consider the evidence presented within the book, or from the broader literature (Baum, 2022). Certainly, some critiques of this approach suggest that speculative figures such as these may actually lead to the severe underestimation and, ultimately, deprioritisation of risks. One such example was argued by Cassidy & Mani (2022), for the recurrence of civilization-threatening volcanic eruption, suggesting the risk to be as high as 1 in 6 this century, compared to 1 in 10,000 presented by Ord. As such, Cassidy and Mani argue, wild underestimations of the risk can result in hazards like large volcanic eruptions to be deprioritised for risk reduction and mitigation funding.

Presenting existential risks in a probabilistic framework as Ord does is intended to elucidate outcomes and as such does not (and is not meant to) account for more nuanced views of interconnectedness between hazards and vulnerabilities, or the mechanisms and pathways involved. Applying this to Ord's examples, there is no consideration of how a pandemic might actually, mechanistically, cause human extinction, or what underlying conditions (say specific pathogen characteristics, or failures and collapses along the way) would need to be fulfilled. This alternative systemic approach to thinking about risk is more widely adopted in the disaster risk literature, as exemplified in the Global Assessment Report for Disaster Risk Reduction (UNDRR, 2022), which pushes for systemic thinking in relation to risk and the cascading impacts that can amplified risk, and echoed in the Global Risks Report from the World Economic Forum (World Economic Forum, 2024).

Within ERS, Tonn & Stiefel (2013) seek to elucidate pathways to human extinction by proposing a "generalised framework" for such risk scenarios. Any scenario, the authors suggest, must be composed of four elements, each with plausibility criteria: *Events*, *Drivers* (forces leading to those events), *Adaptations* to the events, and *Pathways* linking each of these elements. They provide an example of this, positing the initial trigger as a destruction of the world's oil resources (**Figure 3.**) but note that there may well be many other triggers and subsequent compounding events. The overall structure, they argue, is generic and causal, however, and consists of three blocks:

i. **A trigger event** that results in a rapid decline in the human population, due to the collapse of crucial global institutions, including food and health systems, resulting in uncontrolled pandemics and mass starvation.
ii. **Collapse of human civilisation** and humanity's "technological base", alongside further population declines with remaining populations segregated into enclaves.

iii. **An "End-Game" pathway**, where the few remaining humans are unable to adapt and, vulnerable to natural disasters, perish.

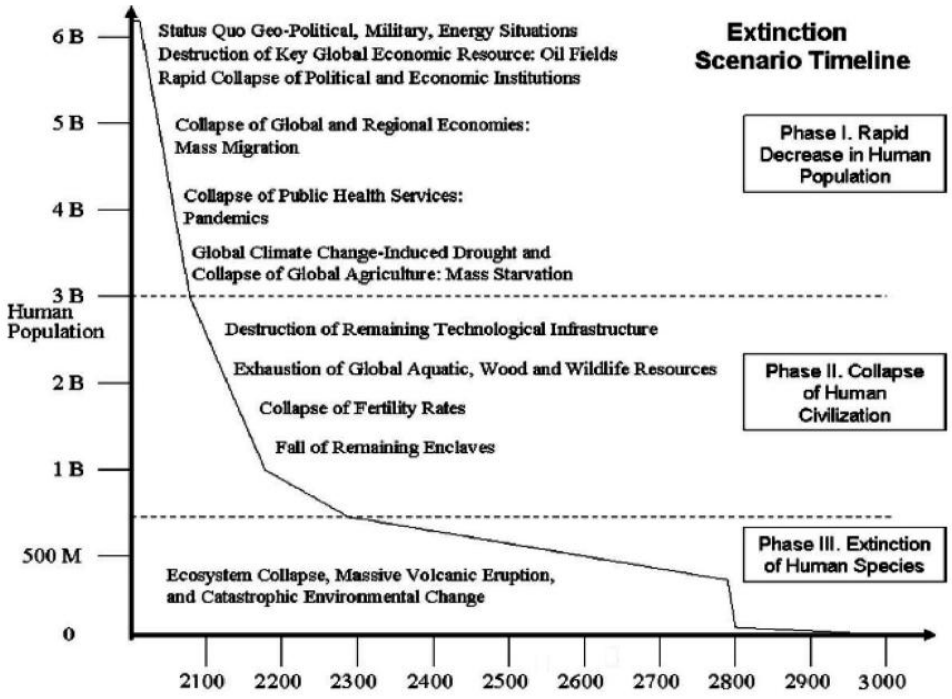

Figure 3. *A stylised human extinction scenario, showing potential generic "phases". Taken from Tonn and Stiefel, (2013).*

Recent years have seen further attempts to think through the dynamic and systemic nature of GCRs and existential risks, aiming to identify the pathways to impact. This approach can help identify where interventions can mitigate the risk and/or increase resilience. In a paper by Liu et al (2018), the authors attempt to address some of the dichotomies around existential risk, and, importantly, consider *vulnerability* and *capacity to cope* as key components within the classifications of existential risks. Using the standard risk equation (where, Hazard x Vulnerability = Risk), they propose that adding an existential magnifier to either Hazard or Vulnerability could create an existential risk (i.e.: (Existential) Hazard x (Existential) Vulnerability = Existential Risk). This framing has been influential for numerous authors in the field to consider components of vulnerability in defining and classifying GCRs and existential risks (Kemp et al., 2022; Mani et al., 2021).

In a 2018 paper, Avin et al take this approach further, by proposing a way to classify GCRs along three dimensions: critical systems affected, mechanism of global spread, and failures of prevention or mitigation (Avin et al., 2018). By drawing out these three elements ("component factors"), the authors argue that it is then more possible to discover convergences and knowledge gaps than by concentrating on hazards alone or on individual GCR scenarios. **Figures 4a and 4b** show some of the factors that the authors of this study identified as 'critical systems' and as 'prevention and mitigation fragilities', though they acknowledge that there are certainly many more to consider. Moreover, the authors point to the need to include multi-disciplinary input into understanding these "interdependent and complex human factors" (Avin et al., 2018).

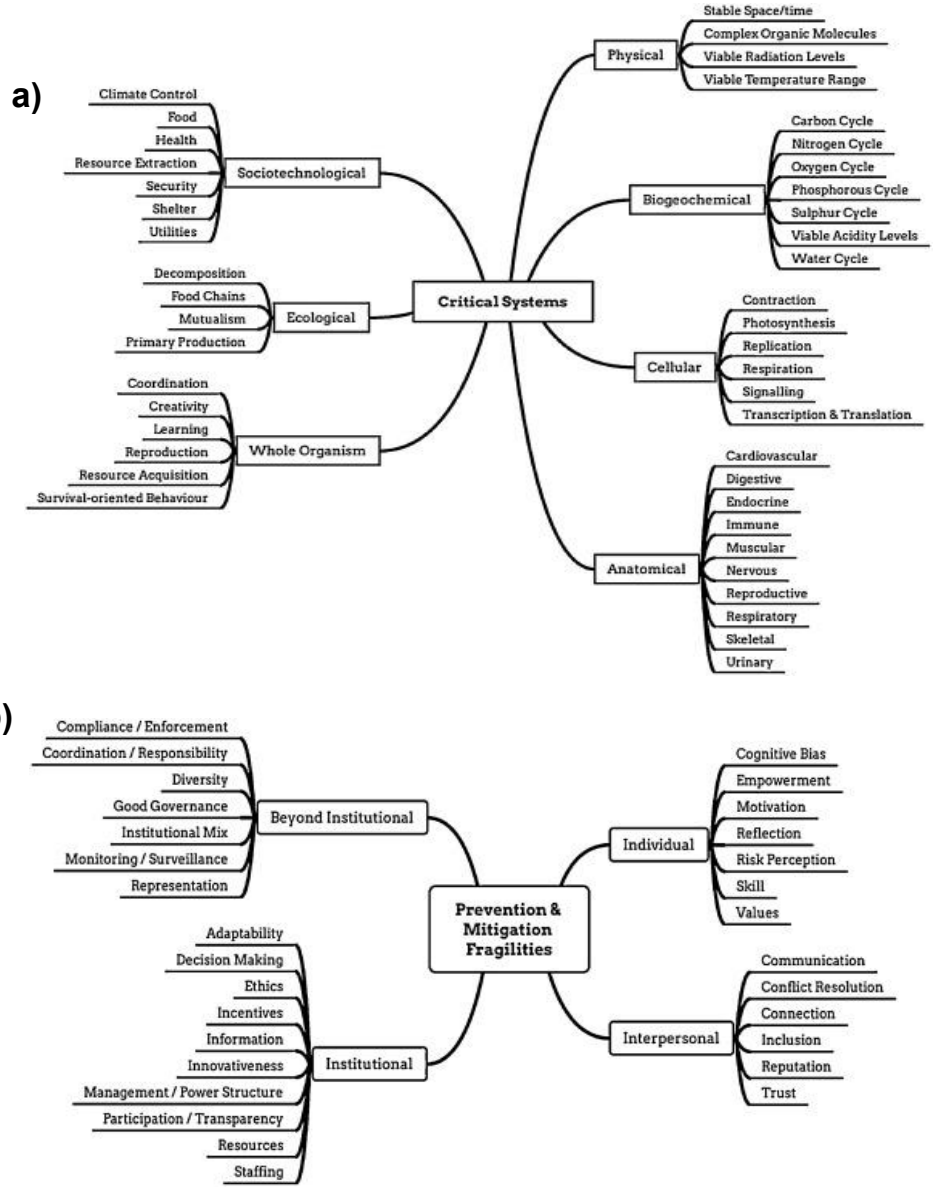

Figure 4. *Component factors taken from Avin et al. (2018) that show the (a) a categorisation of critical systems that can aid identification of global catastrophic risks and, (b) the prevention and mitigation fragilities that can moderate global catastrophic risks.*

An example the authors give is of a major asteroid impact where the path from this hazard to catastrophic outcome would, according to this analytical framework, depend on three factors: a) the unavailability of technological countermeasures to the impact itself (*mitigation failure*); b) a large-area dust-cloud arising from the impact (*global spread*); and c) the disruption of global food systems through the blocking action of that dust cloud (*critical system affected*). What this framework seeks to identify, therefore, are critical paths and nodes that might be at risk of failure when under threat from a variety of hazards, thus identifying nodes where building resilience may reduce exposure to GCRs.

This more holistic approach has been applied across the field in recent years including in Blong's analysis of four indicative routes to global catastrophic risk: sea level rise, a large magnitude volcanic eruption, a pandemic, and a geomagnetic storm (Blong, 2021). The author particularly focuses on the component strands making up these potential GCRs'

interconnected impacts and ‘reach’, bringing them together, encompassing biophysical, socio-economic and cultural focus (**Figure 5)**.

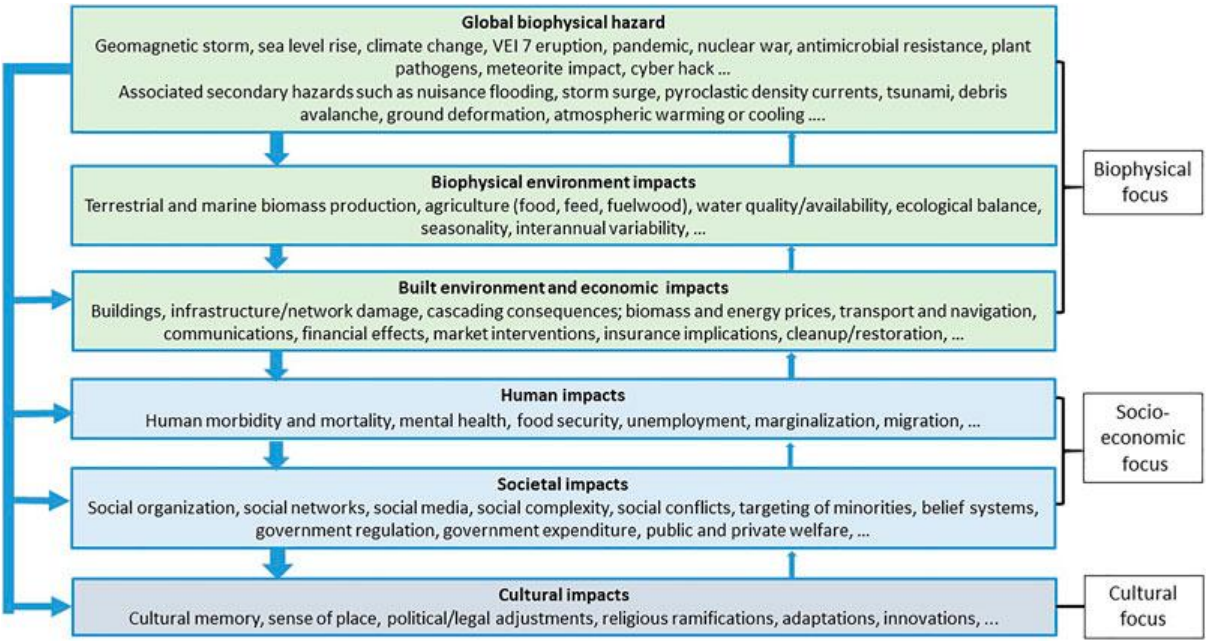

Figure 5. *Blong’s approach to considering the biophysical, social-economic and cultural strands of a global catastrophic risk, from Blong (2021).*

Another particularly influential study also used this holistic way of thinking to demonstrate how volcanic eruptions in proximity to clusters of global critical systems could cause cascading system failures in regions defined as ‘pinch points’ (Mani et al., 2021), calling into question the predominant narrative that only super-volcanic eruptions might result in globally catastrophic impacts. The study adopts the lens of vulnerability (employing the framing of ‘existential vulnerabilities’ from Liu et al (2018) to identify regions where a convergence of ‘global critical systems’ (e.g. global shipping lanes and submarine cables) present potential tipping points by which cascading impacts caused by a volcanic eruption could be amplified from local or regional to global impact. Similar approaches have also been applied to assessing the contributions climate change has on GCRs, creating so-called ‘global system death spirals’ – feedback loops whereby the energy and resources required to reverse or adapt to the impacts outstrips our societal capacities to cope (Beard et al., 2021). Although helpful in helping define the global catastrophic risk landscape, these more holistic approaches of considering the indirect cascading impacts caused by hazard events, presents unique challenges for how these risks many be managed; we explore this in the next section.

Recently, Arnscheidt et al (2025) have sought to bring together the strands of research that are traditionally outcome- or hazard-focused with those that seek to understand the emergence of systemic risk, underscoring the notion that many–if not most–contributors to global catastrophic risk are best understood as existing and operating *within* the global system. In the framework that the authors propose, drawing on research from Complex Adaptive Systems, understanding systemic contributions to global catastrophic risk rests on a nuanced understanding of hazards, vulnerabilities and their interactions.

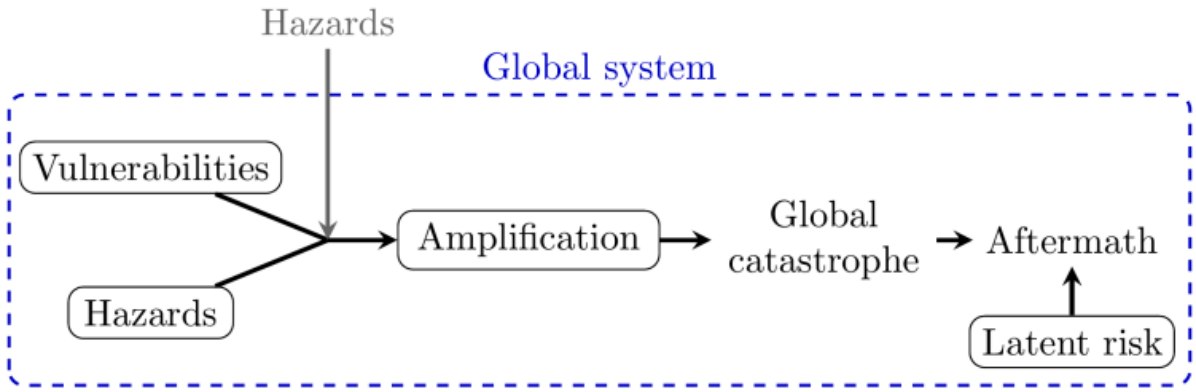

Figure 6. *Arnscheidt et al's proposed framework for understanding the relationship between global catastrophic risk and systemic risk, from Arnscheidt et al (2025).*

Under this model, "hazards, whether from outside of the global system (e.g. asteroids, volcanic eruptions) or emerging within the global system [...], can interact with vulnerabilities [...] to produce GCR. A key component of the interaction between hazards and vulnerabilities is amplification [...]. Finally, latent risk [...] is risk which may be generated by present-day phenomena but only becomes active in certain future system states: this may be particularly important in the aftermath of a global catastrophe. An important point is that each of these four phenomena (hazards, vulnerability, amplification, and latent risk) is in large part emergent from the global system" (Arnscheidt et al., 2025).

4. Who is responsible for global catastrophic risks?

The mitigation of many global catastrophic risks will require a global response. As discussed in this piece, the scope of these risks is wide-ranging, their nature systemic, and their impacts multi-generational. Boyd & Wilson (2020) argue that the mitigation of global catastrophic risk is a "global public good" and that those that stand most to benefit the most from mitigation of such risks are future generations. However, some of these risks manifest in the present, and require mitigation and coordinated management now. In this section, we present the current landscape for global catastrophic risks governance and management and present some examples of how this is applied within some global catastrophic risk domains.

4.1. Are global catastrophic risks governed?

The governance of existential and global catastrophic risks tends to proceed on a 'per-hazard' or 'per-hazard-class' basis. In a large-scale exercise mapping global governance for GCRs, Kemp & Rhodes (2020) distinguish between this kind of governance (which they saw as usually governed by "Regime Complexes"; we describe a few such below) and of "Drivers and Vulnerabilities". This second component, whose governance is crucial since–as was explored above–it often represents the means by which hazards can reach catastrophic outcomes, is nevertheless much less 'cleanly' governed than specific hazards or hazard-classes (and these are themselves messily governed). Even as global catastrophic and existential risks are more widely acknowledged, governance of these risks remains fragmented and, in many cases, insufficient to manage the risks. According to Kemp & Rhodes (2020), "several GCR hazards […] are covered by international law but usually inadequately. That is, the institutions often lack clear enforcement and compliance mechanisms". Boyd & Wilson (2020), echo this point, suggesting that whilst local-scale risk management for some hazards is warranted, many require global response and coordinated management.

There are a number of levels at which the governance of either hazards or drivers/vulnerability can operate, and relevant institutions may not even recognise that areas under their purview could reach the catastrophic or existential scale. For some risks, the processes of governance are far more advanced than others: in this review we present examples of relatively more advanced governance: biosecurity and nuclear warfare. Even in these cases, however, it is unclear whether this governance considers scenarios as extreme as those that might lead to globally catastrophic, let alone existential outcomes.

For many other subject areas, even 'small-scale' governance is still lacking, and we therefore also identify some such areas where gaps remain. It is almost impossible to state with certainty who the relevant duty-bearers for GCRs or existential risks would be, as they have not happened yet and so, there are no data to draw from. Smaller-scale catastrophes are our only guide here and, largely, responsibility for governance lies with the State in, for example, instituting pandemic preparedness plans. In terms of the cascading consequences, these tend to be focused on national resilience planning, or strengthening specific sectoral responses such as national grids (CSER, 2017; Ord et al., 2021).

Certainly, these hazards–and the interactions between them–require attention and proactive governance and resilience building (Avin et al., 2021). Efforts in this domain are not wasted, as preparedness measures such as the strengthening of global economic systems, can have a trickle-down effect for building our resilience and capacity to cope with lower-impact high-frequency risks.

4.2. How are global catastrophic risks governed?

4.1. Governance of Global Catastrophic Biological Risks

GCBRs would likely operationally be governed both internationally and nationally by a number of overlapping entities but this governance usually corresponds to the nature of the hazard, rather than to the (catastrophic or existential) scale and scope of the possible outcome. For example, a small-scale use of biological weapons would be under the remit of the Biological and Toxin Weapons Convention (BTWC), despite potentially not being classed as a GCBR as described above.

For biological threats used in a deliberately harmful manner, the chief forum for international governance is the BTWC. This entered into force in 1975 and prohibits "development, production, acquisition, transfer, stockpiling and use of biological and toxin weapons". Beyond being solely a ban on such weapons, the BTWC also includes within its provisions measures for assistance, response and preparedness to biological threats (Article VII). However, the BTWC lacks a verification regime, and its low operating budget is a frequent cause for concern that may limit its effectiveness. Absent verification, the main mechanism for responding to alleged or actual biological weapons uses is through Article V of the Convention, which enjoins State co-operation in resolving disputes, or escalation to Article VI which involves lodging a complaint (with evidentiary support) to the United Nations Security Council.

Both were invoked (Article VI for the first time) over the course of 2022 by the Russian Federation, whose longstanding allegations of treaty noncompliance by Ukraine and the United States took on a formal character that year (Zanders, 2022b). The Russian Federation convened a Formal Consultative Committee under Article V of the BTWC and subsequently filed an Article VI complaint with the United Nations Security Council, with an associated

resolution proposing an investigation. The FCM did not reach consensus, and the draft resolution was rejected largely due to a lack of evidentiary support. The incident is further complicated by UNSC's processes, and the Russian Federation's position as a permanent member, and has prompted discussion over these two Articles' implementation and utility (Zanders, 2022b).

As such, what action might be taken and by whom in the face of treaty violations remains untested, but is nevertheless presumed to be based on Security Council deliberations. Whatever this action might be, it is plausible that it would involve attribution of biological weapons uses and punitive action; how responses might be managed is covered extremely generally in Article VII, requiring that States support each other in the event of BWC violations. As noted in a United Nations Office on Disarmament (UNODA) report on the subject, the Covid-19 pandemic has prompted many States to examine how Article VII might be operationalised in the event of deliberately released pathogens, operationalisation that, according to Zanders "still requires considerable work" (Zanders, 2022a). One attempt to do this is the Bio-Emergency Management Framework for deliberate events (BEMF). This is envisaged as non-binding, non-prescriptive and informal, but nevertheless a framework for coordinating the many entities that would likely be involved in any response to a deliberate use of biological weapons in different forms (targeting human health or animal health or plants, for example) (UNODA & BWC-ISU, 2019). A diagram of how the various organisations' mandates might be organised under the BEMF is shown in **Figure 7**[3]. Further BEMF operational details, such as specific scenarios, are in the relevant BEMF documents but these are internal to UNODA, the BWC-ISU and the project participants (Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, 2020). It is plausible, however, that in the event of a deliberately caused human pandemic, the response mechanism proposed through BEMF would require large-scale mobilisation of health-resource not dissimilar to those mobilised in the face of a 'natural' pandemic. Therefore, it is likely that, apart from the potential punitive aspects of attribution of an attack (mediated through the BWC and UN Security Council), the *response* would be mediated through public health organs and would largely correspond to the WHO's pandemic response mechanism, discussed in the context of Covid-19 in **Section 4.3.2**. The situation would be different in the case of a non-human-affecting disease agent.

Security Council Resolution 1540 seeks to address a similar issue as the BTWC but with, as its focus, non-state actors. It enjoins States to take effective action to ensure non-proliferation of nuclear, chemical or biological weapons especially where these weapons might be used by terrorist groups. Again, these need not be catastrophic in scale to be 'covered' by this

[3] The organisations involved in the development of the BEMF, a UNODA project co-ordinated by the BTWC's Implementation Support Unit and funded by the Canadian Weapons Threat Reduction Programme are: "Executive Office of the Secretary-General, UN Department for Safety and Security, UN Interregional Crime and Justice Research Institute, UN Operations and Crisis Centre, UN Office for the Coordination of Humanitarian Affairs and UN Environment/OCHA Joint Unit, UN Office of Counter-Terrorism (UNOCT), UNODA, UN Office of Legal Affairs (UNOLA), Food and Agriculture Organization of the UN, International Criminal Police Organization , International Plant Protection Convention Secretariat, World Organisation for Animal Health, Organisation for the Prohibition of Chemical Weapons (in circumstances relevant pursuant to the Chemical Weapons Convention), and the World Health Organization. A dialogue has also been undertaken with the Inter-Agency Standing Committee Secretariat, the International Committee of the Red Cross, the International Organization for Migration, the UN Department of Political and Peacebuilding Affairs and the World Food Programme."

Resolution: it is included here as a relevant policy instrument because nuclear and biological weapons especially have been noted as potential sources of catastrophic or existential risks.

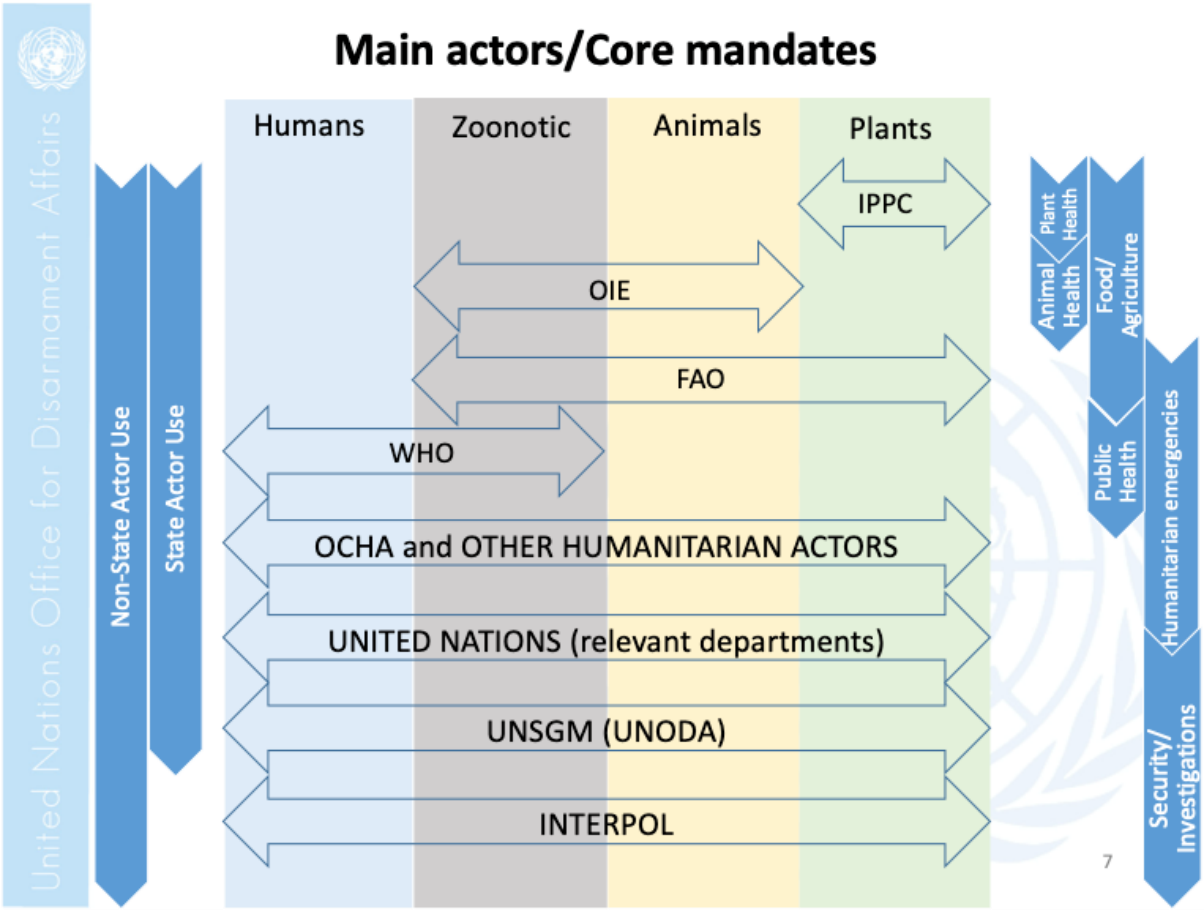

Figure 7. *Main actors and their core mandates in the proposed Bio-Emergency Management Framework for deliberate events, dealing with a number of scenarios across potential threat and actor categories. OIE is the founding name of the World Organisation for Animal Health (WOAH) (UNODA & BWC-ISU, 2019).*

The World Health Organisation is obviously the focal point in dealing with GCBRs to do with human health, including pandemics. Given that pandemics have been identified by several groups working on GCRs and existential risks as particularly relevant hazards, it is worth exploring the global response mechanism here in more detail. Covid-19, while it would not under most definitions (See **Section 2.2.**) meet the threshold of a GCR, is nevertheless an important indicative case in a field with so few priors. As noted above, the WHO is the main United Nations body tasked with responding to pandemics; it does so through the announcement of a Public Health Emergency of International Concern (PHEIC) and through the application of the (legally-binding) International Health Regulations (IHR).

The overall impetus for an outbreak being declared a PHEIC is that it is “an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease and to potentially require a coordinated international response”.

In the first instance, Member States are to notify the WHO of a *potential* PHEIC according to a decision instrument in the IHR as amended in 2024. This decision instrument provides an evaluation metric for scoring on four topics:

1. Geographical scope / risk of territorial spread
2. Characteristics of the event- whether it is rare, reemerging, presents changes in its epidemiological profile and/or has serious health impact
3. Healthcare relevance - whether the event risks compromising the delivery of healthcare and/or poses a risk to health professionals
4. Social and Economic Relevance - whether the event affects vulnerable populations, has high social impact and/or poses a risk to international travel or trade.

If the score is above 11, an event is considered to be a *potential* PHEIC and the WHO must be notified. Following notification, the Director General of the WHO makes the decision of whether to announce a PHEIC; the IHR specify that the decision should consider a number of sources of information, including advice from the Emergency Committee, scientific principles and evidence, as well as "an assessment of the risk to human health, of the risk of international spread of disease and of the risk of interference with international traffic" (World Health Organisation, 2024a).

For Covid-19, in response to the detection of a novel coronavirus that appeared to be crossing borders, the WHO convened a series of IHR Emergency Committee (EC) meetings: the aim of these meetings was to determine whether the outbreak was a PHEIC, a decision taken by the Director General of the WHO, by custom based on the recommendations of the EC.

There has been criticism of the process as not being transparent or consistent and of being too "all or nothing" (Mullen et al., 2020). Nevertheless, it was, for Covid-19, and remains, the primary mechanism to trigger a global response to a pandemic and would likely be invoked in the event of any health-related GCR.

What the triggering of a PHEIC means operationally is less clear and has differed over past instances (which include H1N1, Ebola, Zika) (Mullen et al., 2020). In the main, a PHEIC declaration is seen as a facilitator of coordination—especially when it comes to emergency-use countermeasures—rather than an implementation-specific tool. It "implies the issuance of Temporary Recommendations to States Parties - which, by definition, are not legally binding - to guide them in preparing and responding to the PHEIC" (World Health Organisation, 2024b).

As well as empowering the declaration of a PHEIC, the IHR are intended to ensure the setting-up and evaluation of thorough and robust national pandemic preparedness plans and "core capacities" through WHO-coordinated, voluntary Joint External Evaluations (JEEs).[4]

Unfortunately, these have not been subject to enforcement (by WHO or any other body) and "many countries only applied the IHR in part, were not sufficiently aware of these regulations, or deliberately ignored them" (Aavitsland et al., 2021). Reviews of pandemic preparedness, albeit contentious, such as the Global Health Security Index reflect this, finding that many countries are "dangerously unprepared for meeting future epidemic and pandemics threats" (Bell & Nuzzo, 2021). In response to Covid-19: Whether or not countries enacted preparedness and response plans according to IHR guidelines, whether or not countries'

[4] These "Core Capacities" are: Legislation and Financing; IHR Coordination and National IHR Focal Point Functions; Zoonotic events and the human–animal interface; Food safety; Laboratory; Surveillance; Human Resources; National Health Emergency Framework; Health Service Provision; Risk Communication; Points of Entry; Chemical Events; Radiation Emergencies.

submissions to the WHO under their IHR requirements corresponded to what was actually implemented in the face of Covid-19, it is nonetheless the case that countries acted more or less independently in their response. This response included, among other measures: distancing protocols, mask mandates, workplace/school closures, travel restrictions and curfews. There were other factors at play that are not typically thought of as 'governance' however. For example, the legal governance of travel restrictions under IHR is complex, although most–if not all–countries restricted travel during Covid-19. Moreover, decisions by individual airlines to cease operations to/from certain countries or regions resulted in *de facto* travel restrictions. There are efforts underway to improve pandemic preparedness and response especially in the overarching frameworks to guide these.

A notable example has been the proposed WHO Pandemic Agreement. After over three years of intense and often contentious negotiations, the Intergovernmental Negotiating Body finalised a proposal in April 2025, which will be presented to the World Health Assembly in 2026.

"Proposals [...] include establishing a pathogen access and benefit sharing system; taking concrete measures on pandemic prevention, including through a One Health approach; building geographically diverse research and development capacities; facilitating the transfer of technology and related knowledge, skills and expertise for the production of pandemic-related health products; mobilizing a skilled, trained and multidisciplinary national and global health emergency workforce; setting up a coordinating financial mechanism; taking concrete measures to strengthen preparedness, readiness and health system functions and resilience; and establishing a global supply chain and logistics network."

(World Health Organisation, 2025).

4.2. Governance of nuclear weapons

Similarly to GCBRs, the capacity to engage in nuclear warfare is governed by both national and international entities, supported by legislation including for general prohibition of nuclear weapons, multilateral and bilateral agreements.

Those principally responsible for managing the risk of nuclear war are national governments and the militaries of the nuclear armed states responsible for nuclear posture and doctrines, and the decisions for the release of weapons, along with military personnel responsible within nuclear command and control systems. Within NATO specifically there is a Nuclear Planning Group that discusses NATO nuclear doctrine, but decisions on nuclear release remain with national governments. The UN Security Council has "primary responsibility for the maintenance of international peace and security" under Article 24 of the UN Charter. Increasingly a large number of states are challenging the nuclear order and demanding global disarmament, having established the Treaty for the Prohibition of Nuclear Weapons in 2017.

The approach to international governance of nuclear capacity mainly focuses on the reduction of nuclear arsenals with the goal of the non-proliferation of nuclear weapons and reaching complete global nuclear disarmament.

Bilateral agreements between the US and Russia/Soviet Union have long contributed to a cap on the numbers of nuclear weapons during the Cold War, and, alongside unilateral Presidential Nuclear Directives in 1991 led to significant reductions since. The two states still account for well over 90% of global arsenals. In recent years, the US and Russia have pulled out of many

of the bilateral agreements once forged between them, including the anti-ballistic missile treaty, and the treaty banning the deployment of intermediate-range forces. Only one bilateral agreement remains–New START–which caps the Russian and US arsenals and ensures continued inspections.

The Nuclear Non-proliferation Treaty (NPT) signed in 1968 and entering into force in 1970 is often referred to as the cornerstone of the international nuclear control regime. It recognises the possession of nuclear weapons by those five states that had tested them by 1968 (US, Russia/Soviet Union, UK, France and China), but commits them to complete disarmament "at an early date". Whilst the treaty has near-universal adherence, there remain important hold-outs: India, Pakistan and Israel, alongside former member North Korea, all of whom deploy nuclear arsenals. Past NPT review conferences have agreed extensive action plans involving disarmament measures, reduction in the salience of nuclear weapons, measures to block their development, tighter controls on sensitive technologies, and measures to improve access to peaceful uses. Enforcement is the preserve of The UN Security Council, although this has focused entirely upon non-proliferation standards and has not been used to enforce the disarmament obligations of the five recognised nuclear weapon states (who are also the veto-wielding permanent members). Civil nuclear activities are policed by the International Atomic Energy Agency (IAEA) responsible for inspections and verification (IAEA, 1956).

The UN Treaty on the Prohibition of Nuclear Weapons (TPNW), or nuclear ban treaty, was instigated in July 2017, and now has 91 signatory states and 68 state parties (as of November 2022). The treaty lays out a comprehensive set of prohibitions for member states including the development, testing, production, acquiring, possession, stockpiling, use of, or threatening use of nuclear weapons.

There is an extensive network of nuclear weapon free zones covering much of the earth's surface (and entirely the southern hemisphere). The treaties cover the following regions: Latin America (the 1967 Treaty of Tlatelolco), the South Pacific (the 1985 Treaty of Rarotonga), Southeast Asia (the 1995 Treaty of Bangkok), Africa (the 1996 Treaty of Pelindaba), and Central Asia (the 2006 Treaty of Semipalatinsk). Mongolia is also nuclear-weapon-free.

Nuclear treaties sit alongside other measures addressed at the means of delivery (missiles), such as the Missile Technology Control Regime (MTCR) and the Hague Code of Conduct. More work needs to be done to understand how nuclear security postures themselves, by rejecting a No First Use stance, and by manipulating the risk of nuclear engagement as a strategy of nuclear deterrence, themselves contribute to risk of nuclear war as well as of such conflict spiralling out of control with the consequence of posting significant existential risk.

4.3. How is global response to global catastrophic risk coordinated?

To-date humanity has had little need to stress-test global coordination in the face of a global catastrophic risk. However, we can gain some insight into how this might be conducted by looking at the planetary defence community, who are advancing their global coordination toward asteroid risk, and from the Covid-19 pandemic.

4.3.1. Lessons from Planetary Defence

The field of planetary defence, which seeks to develop counter measures for catastrophic Near-Earth Object (NEO) impacts, regularly use scenario exercises to stress test their national

and global response mechanisms. The Federal Emergency Management Agency (FEMA) and the Planetary Defense Coordination Office (PDCO) at NASA coordinate frequent high-level tabletop exercises designed to stress-test US response to asteroid impact. Through these exercises (now on their fifth iteration), and along with regular scenarios run with the wider international planetary defence community at their bi-annual conferences, a need for improved international community coordination was identified. In 2013 at the UN General Assembly the Committee on the Peaceful Uses of Outer Space made a series of recommendations to this effect, leading the establishment of two new networks, International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) (Mani et al., 2023). Comprising over 71 signatories, IAWN brings together organisations from the international community to facilitate the discovery, monitoring and physical characterisation of hazardous NEOs. Should an NEO be discovered on a course with Earth, IAWN would be activated, to monitor, and assess the risk, and coordinate campaigns for the surveillance of potentially hazardous objects. This mechanism was triggered in late 2024 with the discovery of asteroid 2024 YR4 which was believed to have over 1% chance of colliding with Earth, exceeding the threshold for triggering this mechanism. IAWN met in response to the exceedance of the 1% threshold and began to share information with governments and work with the global community to increase observations which ultimately ruled out the risks to Earth by April 2025. SMPAG is facilitated by the UN (and of which the UN Office for Outer Space Affairs acts as the secretariat), and convenes Member States with space agencies to consider possible interventions for mitigating an impending NEO and preparing and engaging the international civil protection community in mitigation planning and preparedness (European Space Agency, n.d.).

Through these simulation exercises and responding in real-time, the planetary defence community has begun to stress-test the global decision-making mechanisms and advance mitigation technologies that would need to be exercised in the case of an impending NEO impact (Ravan et al., 2022). The global coordination in planetary defence is supported by the development of international space missions to test asteroid deflection technologies, such as the Double-Asteroid Deflection Test (DART) mission in December 2022 - our first successful attempt at nudging an asteroid's trajectory. The field regularly also refers to a team of legal experts to pick through global laws and regulations that may prohibit the use of intervention 'devices' in outer space and seeks to understand the pathways to navigate complex legal settings. The field is now working towards the establishment of a disaster management working group to help improve response to NEO threats.

4.3.2. Lessons from the Covid-19 pandemic

Although not a global catastrophic risk, the Covid-19 pandemic was an unparalleled opportunity for humanity to stress-test our response mechanisms to a global pandemic, particularly in the face of systemic risks. Largely, the management of the crisis was conducted at the national government and local levels, with very little global coordination between nation states. Whilst the World Health Organisation (WHO), took on the main role of communication during the pandemic, and provided advice and guidance on how nations could respond, they were not considered 'duty bearers'. An OECD report investigating regulatory co-operation during the Covid-19 crisis highlighted that initial policy responses lacked international coordination, exposing weaknesses in regulatory coordination (OECD, 2020). One such example is the lack of a global warning system for pandemics and infectious diseases meant that response to the initial outbreak in China was slow and inadequate to slow or prevent the rapid global spread of the virus (Fearnley & Dixon, 2020).

Many lessons can be drawn from the Covid-19 pandemic to inform global governance of GCRs, and to this end, a research agenda was published by Rietveld et al (2022), from the Centre for the Study of Existential Risk. The agenda highlights four key areas: pandemic preparedness, early action, vaccines, and non-pharmaceutical interventions, and argues that greater global coordination in many of these areas would likely have significantly shaped the catastrophic trajectory of the pandemic. As the authors explain: “Coordinated measures at the highest levels could have made it easier for countries to take tough measures themselves and explain these to their citizens. Unfortunately, global and regional measures either did not come, came late or were insufficient. Leadership rivalry and contradictory approaches carried the day, whereas cooperative leadership and joint efforts were mostly lacking” (Rietveld et al., 2022). As noted in the earlier section on GCBR governance, attempts are being made to develop better global coordination to face future pandemics, and to face possible deliberate biological threats.

4.4. Gaps in global GCR governance and coordination

As demonstrated in this section, there are some attempts to advance global governance and coordination for global catastrophic risk to varying degrees. However there remain significant gaps in the governance landscape, notably around the advancements in sophisticated technologies such as artificial intelligence. Proposals for this abound, however, with diverse characteristics. In a literature review of these, Maas & Villalobos (2023) developed a typology of institutional models for AI governance, which includes: (1) scientific consensus-building; (2) political consensus-building and norm-setting; (3) coordination of policy and regulation; (4) enforcement of standards or restrictions; (5) stabilization and emergency response; (6) international joint research; and (7) distribution of benefits or access. Even then, areas of risk convergence (such as for instance the role of AI as an amplifier) may not be fully understood or covered.

Boyd and Wilson (2020) note that quite often a lack of governance for some of the risk areas implicated in global catastrophic or existential risk is because they have relatively recently come to the fore as potential risks, whilst mitigation takes time to catch up. They also note that quite simply, survival bias can affect how people perceive risks. After all, if we’ve survived many of these risks until now, why would humanity not continue to survive (Bostrom & Cirkovic, 2011)? Other authors in ERS suggest that, often, longer-term risks are deprioritised due to a lack of incentives among decision makers or the appropriate support structures within national governments to work towards their mitigation (Hilton & Baylon, 2020; Ord et al., 2021), or as misperceptions and mismanagement due to a “Tragedy of the Uncommons” (Wiener, 2016). Whatever the cause, there certainly remain gaps in the risk governance and mitigation landscape for GCRs.

Kemp & Rhodes (2020) identified no governance structures and insufficient regulatory processes to manage many globally catastrophic or existential risks. They provide a list of recommendations to fill some of their identified gaps, including:

- Lack of policy coverage for addressing multiple risks and risk drivers.

- Need for more complete understanding of 'civilizational boundaries' [5] and their tipping points to help governance of extreme risk scenarios.
- Need to better understand the interactions between GCR governance areas, ensuring that actions in one UN-system action on GCRs does not impact upon other bodies.
- Increased adoption of foresight for the UN for GCRs, enabling improved insight into areas for GCR governance.
- Increased study of tail-end risk scenarios and improvement of global preparedness, resilience and response efforts.

5. Conclusion

The field of Existential Risk Studies has grown rapidly over the past decade, with new institutions and researchers focused on assessing and building conceptual understanding of GCRs and existential risks. Despite this, there remains a lack of diversity in the field with most research produced in English-speaking countries, and little produced outside the US and Europe. There also remains a lack of conceptual clarity and inconsistent terminologies and definitions across the field, which can impede coordinated risk governance and response. This becomes a further challenge when considering how to govern complex systemic risks, such as those that may escalate through system shocks. For some risk domains, there has been good progress towards international coordinated governance of some risks, such as biological threats and nuclear weapons, however, gaps remain for a global coordinated response to global catastrophic risk more generally.

[5] 'Civilizational boundaries' could be seen as analogous to the concept of "Planetary Boundaries", conceived by the Stockholm Resilience Centre as processes that define Earth systems' stability and function (Rockström et al., 2009).

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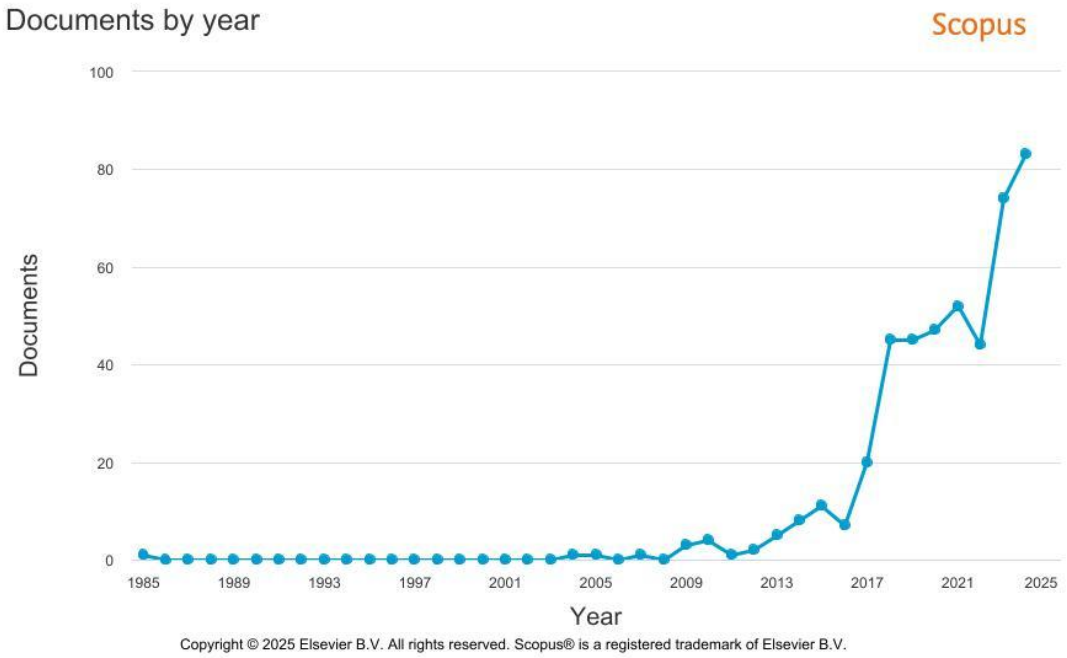
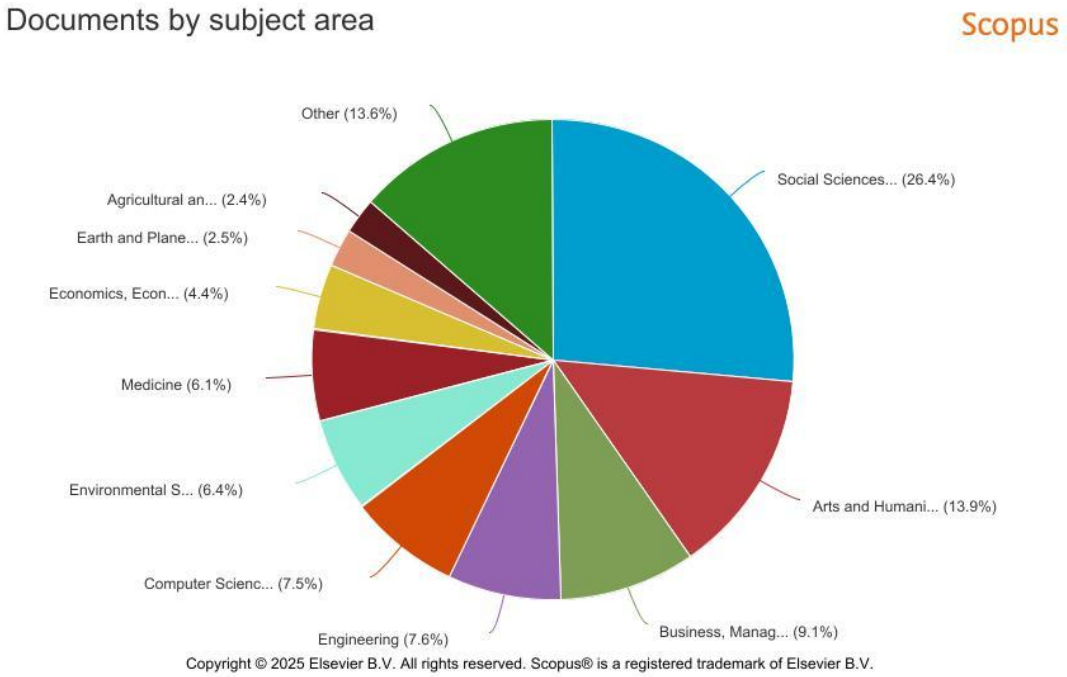
Appendix A - Literature presence

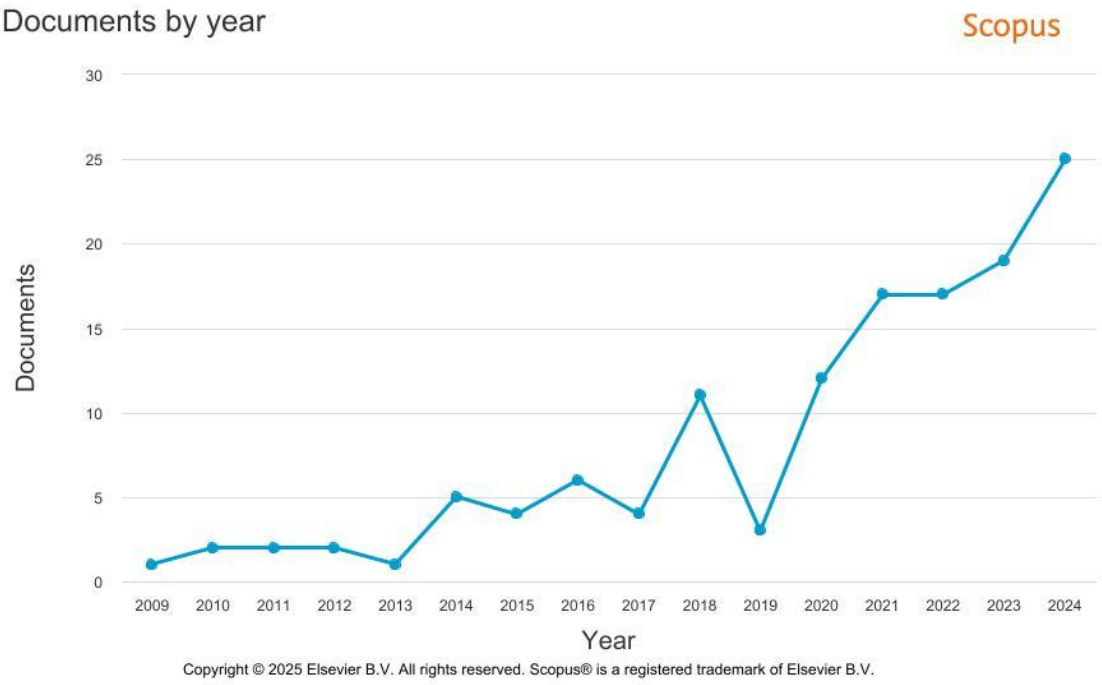
Scopus

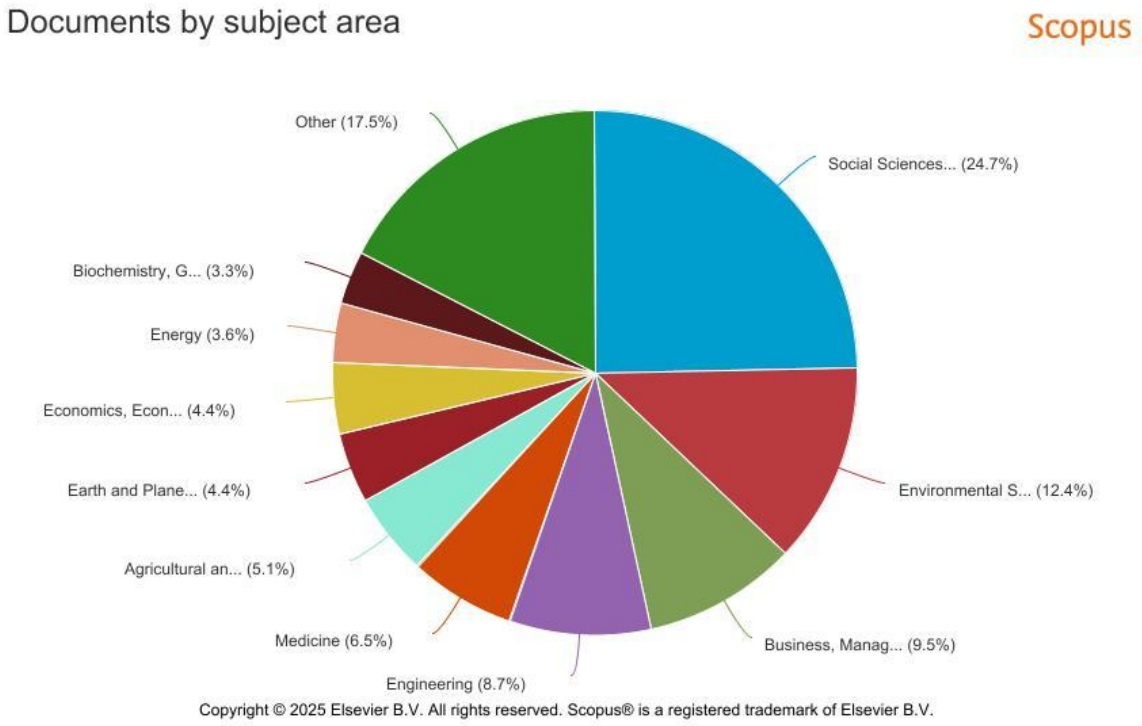
A search of the Scopus data base for **'Existential Risk'** returned a total of 455 documents with the majority of documents from the social sciences.





A search of the Scopus data base for **'global catastrophic risk'** returned a total of 131 documents with the majority of documents from the social sciences.





While searching Web of Science yielded fewer overall publications, the WoS analysis of the journals most usually published in provides a useful snapshot of the topics involved.

Web of Science

The Web of Science (WoS) database yielded fewer overall publications - 244 results for **'Existential Risk'** and 76 results for **'global catastrophic risk'**. The WoS analysis of the journals most usually published in provides a useful snapshot of the topics involved.

Disciplines featured within 'Existential Risk':

Disciplines featured within 'global catastrophic risk':

Appendix B - Existential and Catastrophic Risk-Related Institutions

University-Affiliated Research Institutes mainly dedicated studying existential and global catastrophic risks:
The Centre for the Study of Existential Risk (University of Cambridge)
The Future of Humanity Institute (University of Oxford)
The Graduate School of Advanced Integrated Studies in Human Survivability (Kyoto University)
Centre for Philosophy and the Future of Humanity (Peking University)

University Affiliated Research Institutes where existential risk is a focus of study:
Center for Security and Emerging Technology (Georgetown University)
Stockholm Resilience Centre (Stockholm University)
Copenhagen Center for Disaster Research (University of Copenhagen)
Center for Health Security (Johns Hopkins University)
Center for International Security and Cooperation - Incorporating the Stanford Existential Risk Initiative (Stanford University)
Joint Programme on the Science and Policy of Global Change (MIT)
Center for Human Compatible AI (UC Berkley)
Garrick Institute for the Risk Sciences (UCLA)
School for the Future of Innovation in Society (Arizona State University)
Center for Population Level Bioethics (Rutgers)
Belfer Center for Science and International Affairs (Harvard)
Institute for International and Regional Studies - programme on Global Systemic Risk (Princeton)
Hawaii Research Center for Futures Studies (University of Hawaii Manoa)
Centre for Apocalyptic and Post-Apocalyptic Studies (University of Hamburg)

Independent Research Institutes and Think Tanks:
Future of Life Institute
Global Catastrophic Risk Institute
Berkley Existential Risk Initiative
Carnegie Council for Ethics in International Affairs
OBservatoire des VEcus du COllapse
Institut Momentum
Institutet för framtidsstudier (Institute for Future Studies)
Global Challenges Foundation
African Centre for Disaster Studies
The World Economic Forum
Center on Long Term Risk
The Royal Institute of International Affairs (Chatham House)
School of International Futures
Nuclear Threat Initiative
Riesgos Catastróficos Globales

Other Research Entities focus primarily on specific topics:

- ...focusing primarily on AI...
    - Machine Intelligence Research Institute

    - Institute for Ethics in Emerging Technology
    - Association of the Advancement of Artificial Intelligence
- ...nuclear security...
    - The Bulletin of the Atomic Scientists
- ...environmental risk...
    - The Institute for Advanced Sustainability Studies
    - Breakthrough / Centre for Climate Resilience
- ...systemic complexity…
    - Geneva Global Initiative
    - Santa Fe Institute
    - The International Institute for Applied Systems Analysis
    - The Complexity Science Hub Vienna
    - Cascade Institute
- ...and nanotechnology
    - Foresight Institute
    - Center for Responsible Nanotechnology
- Networks
    - Alliance for Feeding Everyone in Disasters (ALLFED)
    - Pugwash (and it's national affiliates)
    - Scientists for Global Responsibility
    - The Millenium Alliance for Humanity and the Biosphere
    - Humans 4 Survival