# Global Catastrophic Risks 2020

Global Challenges Foundation

## GLOBAL CHALLENGES FOUNDATION (GCF) ANNUAL REPORT: GCF & THOUGHT LEADERS SHARING WHAT YOU NEED TO KNOW ON GLOBAL CATASTROPHIC RISKS 2020



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# Contents

# Dear reader,

In 2020, COVID-19 catapulted catastrophic risks and their governance into the global consciousness. The warning signs have been increasingly strong as humans disrupt biodiversity, come into close contact with virus-carrying creatures and travel intensively throughout the world.

The Global Challenges Foundation's Annual Report aims to give an overview of all the greatest threats to humanity, to track developments in the issues, to highlight their interconnectedness and to explore how they are being managed at the global level. The essays illustrate, more than ever, the complex linkages between these global risks and how they can reinforce each other.

This year's survey of global catastrophic risks comes with added significance. As in previous years, we are honored to have collaborated with Professor David Heymann of the London School of Hygiene and Tropical Medicine who has reviewed the chapter on catastrophic pandemics, bringing it up to date with a section on COVID-19.

If ever there were an argument for enhanced global cooperation to tackle catastrophic risks, COVID-19 is it. The pandemic respects no borders and underlines our interdependency. No one is truly safe until everyone is protected – which means vaccines and treatment must reach everyone, a massive collective undertaking.

But what of other pressing risks, notably the climate crisis which finally and belatedly topped the global agenda last year but has since been largely overshadowed by the race to contain the virus? The pandemic will likely lead to a reduction in global carbon emissions in 2020. But how could it affect climate change in the medium to long-term?

There is of course a serious risk that political and public attention for climate issues will dramatically decline in the face of the acute economic and social consequences of the pandemic. And yet some of us believe that this crisis can be a turning point, giving rise to a greener future as the economic recovery packages being prepared by many countries offer an opportunity to re-build economies and societies towards sustainable modes of production and consumption.

As debates continue about the best way to manage the greatest threats to our species' existence, one thing is certain: we will need to build new forms of global governance, more urgently and more creatively than ever envisioned. The Global Challenges Foundation will continue to promote understanding and joined-up thinking about how we manage and govern these threats.

We will be feeding into ongoing global discussions on these themes. As the United Nations marks its 75th anniversary this year, at a time of great disruption for the world, UN Secretary-General António Guterres has launched the 'UN 75' initiative. It promises to be the largest and most far-reaching global conversation to date on "The future we want – the UN we need". We are contributing to this debate by supporting the UN and the important work of one of the teams that won our 2017 'New Shape Prize' to remodel global governance for the 21st century.

This multinational team of experts - economist Augusto Lopez Claros, scientist Arthur Dahl and international lawyer Maja Groff - is examining the key structural changes needed for the UN to effectively address the greatest challenges of our time. They are developing an integrated set of proposals to review the UN Charter which would aim to give the UN the binding legislative, judicial and enforcement functions to effectively address catastrophic risks, while still reserving most functions to states.

As well as UN reform, GCF is specifically addressing climate governance by setting up a Climate Governance Commission. The Commission will diagnose obstacles to effective climate action and propose global governance responses. It aims to develop and mobilise support for a number of proposals for the improvement of global decision-making and cooperation to stimulate effective solutions to the climate crisis. The Commission will include expertise not only from climate experts, but also from experts on economics, the social sciences, global governance, public policy, diplomacy, business and the labor market. The aim is to kick-start progress in the failing international process to end catastrophic climate changes.

We hope you find this report thought-provoking as a summary of the latest evidence on the risks we face. We are sincerely grateful to all the scientists and experts who have helped us - and who continue to help us - in fulfilling our mission. This is an urgent global discussion that must accelerate from here.  We invited these respected experts to inform and explain the risks as a catalyst for a more intensive and urgent global discussion.  As we continue to support research and policy development, we welcome your feedback and contributions.

Thank you.

Jens Orback

**If ever there were an argument for enhanced global cooperation to tackle catastrophic risks, COVID-19 is it.**

**JENS ORBACK**
Executive Director, Global Challenges Foundation

# Taxonomy

This report aims to present an overview of the global catastrophic risks that the world currently faces, based on consideration of certain crucial facts and the latest scientific research. It proposes to complement the World Economic Forum's Global Risks Report[1], which offers an up-to-date picture of global risks as perceived by leading political and economic actors. These two approaches are highly complementary: perception is a strong driver of collective action and decision-making, while a more focused examination of the risks themselves will guide better long-term strategy and support the design of more efficient governance models.

When preparing this report, we aimed to develop a taxonomy that would reflect the best current understanding and be useful to decision-makers. We combined historical evidence and scientific data to decide which risks should be included in the report. For the sake of clarity, we identified ten key risks, which we then organised into three main categories: current risks from human action, natural catastrophes, and emerging risks. The reader should keep in mind, however, that many of those risks are closely interconnected, and their boundaries sometimes blur, as with climate change and ecological collapse, or as in the case of synthetic biology, which could be presented as a risk of its own, an additional risk factor in biological warfare, or a potential cause for engineered pandemics.

The report offers a description of the current risks, exploring what is at stake, what is known, and key factors affecting risk levels. Then, for each risk, the report considers current governance frameworks for mitigating the risks. Each section was prepared in collaboration with leading experts in the field.

## CURRENT RISKS FROM HUMAN ACTION

Weapons of mass destruction – nuclear, chemical and biological warfare – catastrophic climate change and ecological collapse are all current risks that have arisen as a result of human activity. Although action on them is time sensitive, they are still within our control today.

## NATURAL CATASTROPHES

Pandemics, asteroid impacts and supervolcanic eruptions are known to have caused massive destruction in the past. Though their occurrence is beyond human control to a large extent, our actions can significantly limit the scale of impact. This is especially true for pandemics, where the recent experience of COVID-19, Ebola and Zika outbreaks highlighted the challenges and opportunities of global cooperation.

## EMERGING RISKS

Artificial intelligence might not seem like an immediate source of concern. However, we should remember that challenges widely recognised as the greatest today – climate change and nuclear weapons – were unknown only 100 years ago, and late response – as in the case of climate change – has increased the risk level considerably. Significant resources are devoted to further the potential of those technologies; in comparison, very little goes into mapping and managing the new dangers they bring. As we cannot expect the pace of technological development to be linear, and given our limited knowledge and resources, leading experts are pressing for action on those risks today[2].

# Weapons of mass destruction

## NUCLEAR WARFARE

On August 6, 1945, a nuclear bomb exploded in Hiroshima, killing some 70,000 people within the day. In total, almost a half of the city perished from the effects of the bomb, half in the heat, radiation, fires and building collapses following the blast, and another half before the end of the year from injuries and radiation, bringing the total number of deaths to some 150,000[1]. Since then, the world has lived in the shadow of a war unlike any other in history. Although the tension between nuclear states has diminished since the end of the Cold War and disarmament efforts have reduced arsenals, the prospect of a nuclear war remains present, and might be closer today than it was a decade ago[2]. Its immediate effect would be the catastrophic destruction of lives and cities, and debilitation, illness and deaths from radiation, but another concern is the risk that the dust released from nuclear explosions could plunge the planet into a mini ice-age[3], with dramatic ecological consequences, severe agricultural collapse, and a large proportion of the world population dying in a famine[4].

**150,000**

**is the estimated number of deaths caused by the nuclear bomb in Hiroshima on August 6, 1945**

## BIOLOGICAL AND CHEMICAL WARFARE

Toxic chemicals or infectious micro-organisms have been used as weapons to harm or kill humans for millennia, from the ancient practice of poisoning an enemy's wells and throwing plague-infected bodies over the walls of cities under siege, to the horrifying usage of germ warfare during the Second World War in Asia, or the use of nerve gases in the Iran-Iraq War. Biological and chemical attacks not only cause sickness and death but also create panic.

Up to now, their destructive effect has been locally contained. However, new technological developments give cause for concern. In particular, developments in synthetic biology and genetic engineering make it possible to modify the characteristics of micro-organisms. New genetically engineered pathogens – released intentionally or inadvertently – might cause a pandemic of unprecedented proportions.

Reviewed by **KENNETTE BENEDICT**

# Nuclear warfare

## HOW MUCH DO WE KNOW?

Depending on their yield, technical characteristics and mode of explosion, today's more powerful nuclear weapons will cause 80 to 95 per cent fatalities within a radius of 1 to 4 kilometres from their point of detonation, with very severe damage being felt for up to six times as far[5]. The largest arsenals are currently held by the United States and Russia who control approximately 6,500 warheads each[6]. Seven other states are known to possess nuclear weapons or are widely believed to possess them: the United Kingdom, France, China, India, Pakistan, North Korea and Israel[7]. Various scenarios of intentional use are currently imaginable but nuclear weapons could also be released by accident, triggering an inadvertent nuclear war – as has almost happened a number of times since 1945[8].

In addition to their destructive effect at the point of impact, nuclear explosions may cause what is known as a 'nuclear winter'[9], where clouds of dust and sulphates released by burning materials obscure the sun and cool the planet for months or years.

According to one model, an all-out exchange of 4,000 nuclear weapons, in addition to the enormous loss of lives and cities, would release 150 teragrams of smoke, leading to an 8 degree drop in global temperature for a period of four to five years[10], during which time growing food would be extremely difficult. This would likely initiate a period of chaos and violence, during which most of the surviving world population would die from hunger.

Credit/source: Unsplash

## WHAT ARE THE KEY FACTORS AFFECTING RISK LEVELS?

Continued efforts towards arsenal reduction will reduce the overall level of nuclear risk. Attention to geopolitical tensions and rising nationalism, along with continued efforts towards global conflict management, particularly among nuclear states, will reduce the underlying risk of an intentional nuclear war[11]. In addition, controlling and limiting horizontal proliferation[12] will limit the number of potential nuclear conflict scenarios and is highly likely to reduce the overall risk level.

The risk of accidental use depends largely on the systems in place to launch missiles and the growing threats of cyberattacks on command and control systems. Hundreds of nuclear weapons are currently in a state of high readiness and could be released within minutes of an order[13]. Building in longer decision-making time and broader consultation would reduce the risk of unauthorised launches or accidental launches based on misperception or false alarms.

Increased awareness and understanding of the grave effects that nuclear weapons have on human life, economic infrastructure, governance, social order and the global climate would motivate efforts to avoid such catastrophic harm to our societies[14].

# Governance of nuclear warfare

**Kennette Benedict**, Senior Advisor, Bulletin of Atomic Scientists

States currently manage the risks of nuclear weapons through a range of measures that have prevented the worldwide spread of these weapons of mass destruction but have not significantly reduced the risk of catastrophic use.  In fact, recent changes to nuclear doctrine and planned development of new nuclear weapons by the United States and Russia make it more likely that nuclear weapons will be used in military actions, or through miscalculation or accident, than at any time since the 1950s and the beginning of the Cold War.

The pillar of nuclear military strategy is deterrence, whereby nuclear-armed states threaten to retaliate against other states' use of nuclear weapons against them. This doctrine is considered by some to be an effective way of preventing nuclear war. The fact that no nuclear weapons have been used in any conflict since 1945, however, suggests that political restraint and a moral norm also may have played a role in discouraging their use.


As major powers relied on deterrence in their military doctrines, however, international cooperation, beginning with the 1963 US-Soviet treaty to ban atmospheric testing, along with subsequent US-Soviet/Russian bilateral treaties and agreements, has reduced and stabilised nuclear arsenals from a high of 68,000 in the late 1980s to about 14,000 today.

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In addition, the 1970 Nuclear Non-proliferation Treaty (NPT) has prevented the development of nuclear weapons in all countries beyond the original five (United States, Soviet Union/Russia, United Kingdom, France and China) with the exception of India, Pakistan, North Korea and probably Israel. Altogether, some 25 governments have given up their nuclear weapons programmes, including South Africa, Libya, Belarus, Kazakhstan and Ukraine. Another 15, like Canada, Brazil and Argentina, have contemplated programmes but not embarked on them, in keeping with their responsibilities under the NPT.

The UN Security Council, whose permanent members include the five recognised nuclear weapons states, enforces the Nuclear Non-proliferation Treaty in partnership with the International Atomic Energy Agency (IAEA). Although the IAEA was established primarily to promote and oversee the development of civilian nuclear power, it is entrusted with verifying adherence to the Treaty (under Article III). Parties to the Treaty regularly report to the IAEA about the means used to safeguard and secure enriched uranium and plutonium used in civilian power plants, as well as steps to prevent the use of nuclear materials for bombs.

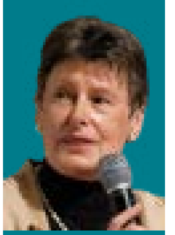
Several states have not complied with their Nuclear Non-proliferation Treaty obligations and faced penalties from the international community. Iraq embarked on a nuclear weapons programme, but, after nuclear bomb technology was discovered in 1991, the weapons were destroyed by a special UN Security Council-mandated force. In the case of Iran, international economic sanctions were applied when suspicions arose about its possible pursuit of nuclear weapons. To prevent Iran from acquiring them, multilateral negotiations produced the 2015 Joint Comprehensive Plan of Action. It mandated reduction of the means to enrich uranium to a minimal level, allowing enrichment only to below weapons-grade. It also ensured continuous IAEA monitoring of Iran's civilian nuclear programme.

As part of an unravelling of nuclear governance, however, the United States has pulled out of the Joint Comprehensive Plan Of Action and Iran has increased production of enriched uranium beyond that stipulated in the agreement.  Even more consequential, the United States has announced its abrogation of the 1987 Intermediate Range Nuclear Forces Treaty with Russia that banned a class of missiles with nuclear weapons capability.  In addition, the United States has not yet announced its interest in working with Russia to extend the 2010 New START, an agreement that places a cap on American and Russian arsenals with provisions for robust inspections. Russia and the United States have each declared their intentions to use nuclear weapons, even if nuclear weapons are not used against them first.  These actions, along with North Korea's continued production of nuclear weapons, despite international economic sanctions, suggest that the norms of restraint may not be as strong as in the past.  In fact, a new nuclear arms race is under way among all of the nuclear weapons states that reinforces the utility of nuclear weapons in war-fighting and increases the risk that these weapons will be used.

This new arms race underscores the difficulties of enforcing the Nuclear Non-proliferation Treaty when countries do not wish to cooperate.  The original treaty suggested a bargain whereby states without nuclear weapons would not acquire them but would have access to civilian nuclear power. In exchange, the states with nuclear weapons pledged to disarm when conditions warranted.  Many believed that the end of the Cold War was such a time, and yet, while nuclear arsenals have radically decreased in Russia and the United States, the recent reversal in doctrine and rhetoric suggest that these and other nuclear weapons states have no intention at present of eliminating their nuclear arsenals.

Even as formal treaties and informal norms of restraint are eroding, however, non-nuclear weapons states have introduced a UN treaty banning all nuclear weapons. One hundred and thirty-five of the 193 member countries participated in the 2017 UN treaty negotiations; 122 countries voted in favour of the final treaty, one against and one country abstained. As of December 2019, 80 countries have signed the treaty and 34 have ratified it, adapting their national legislation to comply with its provisions. The treaty, which is indefinitely open for signing, will take effect when 50 nations have ratified it. Not since the Nuclear Non-proliferation Treaty of 1970 have states taken such dramatic and collective action to prohibit possession of nuclear arsenals

Unfortunately, re-emerging nationalism is spurring the nine nuclear weapons states – none of which participated in or voted on the UN ban treaty – to modernise, increase and lower the threshold to use their nuclear weapons. Such actions reinforce beliefs about the purported utility of nuclear weapons, undermine international cooperative efforts to reduce the risks and seriously increase the probability of catastrophic nuclear war.


Reviewed by
ANGELA KANE

# Biological and chemical warfare

## HOW MUCH DO WE KNOW?

Unlike nuclear weapons, which require rare materials and complex engineering, biological and chemical weapons can be developed at a comparatively low cost[15], placing them within the reach of most or all states as well as organised non-state actors. Chemical and biological weapons carry various levels of risk. Toxic chemicals could be aerosolised or placed into water supplies, eventually contaminating an entire region. Biological weapons possess greater catastrophic potential, as released pathogens might spread worldwide, causing a pandemic.

Recent developments in synthetic biology and genetic engineering are of particular concern[16]. The normal evolution of most highly lethal pathogens ensures that they will fail to spread far before killing their host. Technology, however, has the potential to break this correlation, creating both highly lethal and highly infectious agents[17]. Such pathogens could be released accidentally from a lab, or intentionally released in large population centres[18]. Current trends towards more open knowledge sharing can both contribute to, and mitigate, such risks. The COVID-19 pandemic – while not an engineered pathogen release – has shown us the existential and economic consequences such a pandemic can cause.

## WHAT ARE KEY FACTORS AFFECTING RISK LEVELS?

- Global frameworks controlling research on chemical or biological weapons, including revised strategic trade controls on potentially sensitive dual-purpose goods, technology and materials; biological and chemical safety and security measures; and an ongoing commitment and capacity to enforce disarmament and arms control conventions[19].

- The number of laboratories researching potential pandemic pathogens for military or civilian purposes, along with the public availability of dangerous information circulating for scientific purposes[20].

- Further developments in synthetic biology and genetic engineering lowering skill levels and costs to modify existing pathogens or to develop new pathogens[21].

- Lack of public health preparedness in quickly tackling any potential outbreak of a pathogen release or even a pandemic in order to avoid massive harm to populations.

**Unlike nuclear weapons, which require rare materials and complex engineering, biological and chemical weapons can be developed at a comparatively low cost.**

### CHEMICAL WEAPONS: AN UNRAVELLING CONSENSUS?

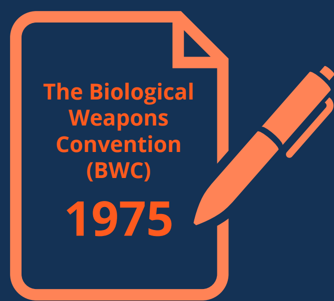
Deadly agents like sulphur mustard were used during and between the World Wars, but the horrific results of such attacks eventually led to a global consensus to ban toxic chemical weapons, the most widely-used and easily proliferated weapon of mass destruction[22].

This consensus, however, represented by the near-universal 1993 Chemical Weapons Convention (CWC) is under strain. The Syrian Civil War has resulted in well-documented and indiscriminate uses of various deadly toxic chemicals against the civilian population, including some 20 children dying from the deadly nerve agent Sarin (or a 'sarin-like' compound). Though the risk may always exist from easily available dual-use chemicals, and from terrorists like the Aum Shinrikyo (now know as Aleph), which perpetrated the Tokyo attack in 1995, there is a global risk that the hard-won consensus on banning state use of toxic chemicals will be further weakened[23].

The international community has established a number of investigative bodies to uncover the facts and determine responsibility, yet attribution remains problematic and until now, no person or entities have been brought to justice. The danger is that the weakening consensus could lead to the devastating use of more advanced toxic chemical weapons of mass destruction in any potential large-scale conflict in the future. It could also cause long-term changes in how states understand the development, evaluation and use of 'non-standard chemical substances' (substances other than deadly substances like sarin) for domestic riot control, counter-terrorism operations, international peacekeeping, and as a mechanism to maintain a standby offensive chemical weapons capability.

# Governance of biological and chemical warfare

**Angela Kane,** Senior Fellow, Vienna Centre for Disarmament and Non-Proliferation; visiting Professor, Sciences Po Paris; former High Representative for Disarmament Affairs at the United Nations





Biological and chemical weapons are banned by two international treaties: the Biological Weapons Convention (BWC) of 1975, with 178 State Parties, and the Chemical Weapons Convention (CWC) of 1997, with 189 State Parties. In both cases, dual-use creates a particular difficulty: the same chemicals and biological agents can be applied for beneficial purposes or serve as the core components of deadly weapons.

The CWC, negotiated with the participation of the chemical industry, defines a chemical weapon by its intended purpose, rather than lethality or quantity. It allows for stringent verification of compliance: acceding to the CWC means mandatory destruction of all declared chemical weapons as well as their production sites – to be subsequently verified by appointed inspectors.

The BWC is less prescriptive, which results in ambiguities and loopholes. Research is permitted under the Convention, but it is difficult to tell the difference between legitimate and potentially harmful biological research. States are required to "destroy or to divert to peaceful purposes" their biological weapons, but no agreed definition of a biological weapon exists. In addition, there is no secretariat to monitor and enforce implementation, except for a small administrative support unit in Geneva. No mechanism exists to verify destruction or diversion, despite efforts since 1991 to include legally-binding verification procedures in the BWC. Some lesser steps have been taken, including confidence-building measures on which State Parties are to report each April, and management standards on biosafety and biosecurity. However, implementation is voluntary and the vast majority of State Parties do not submit declarations on their activities and facilities.

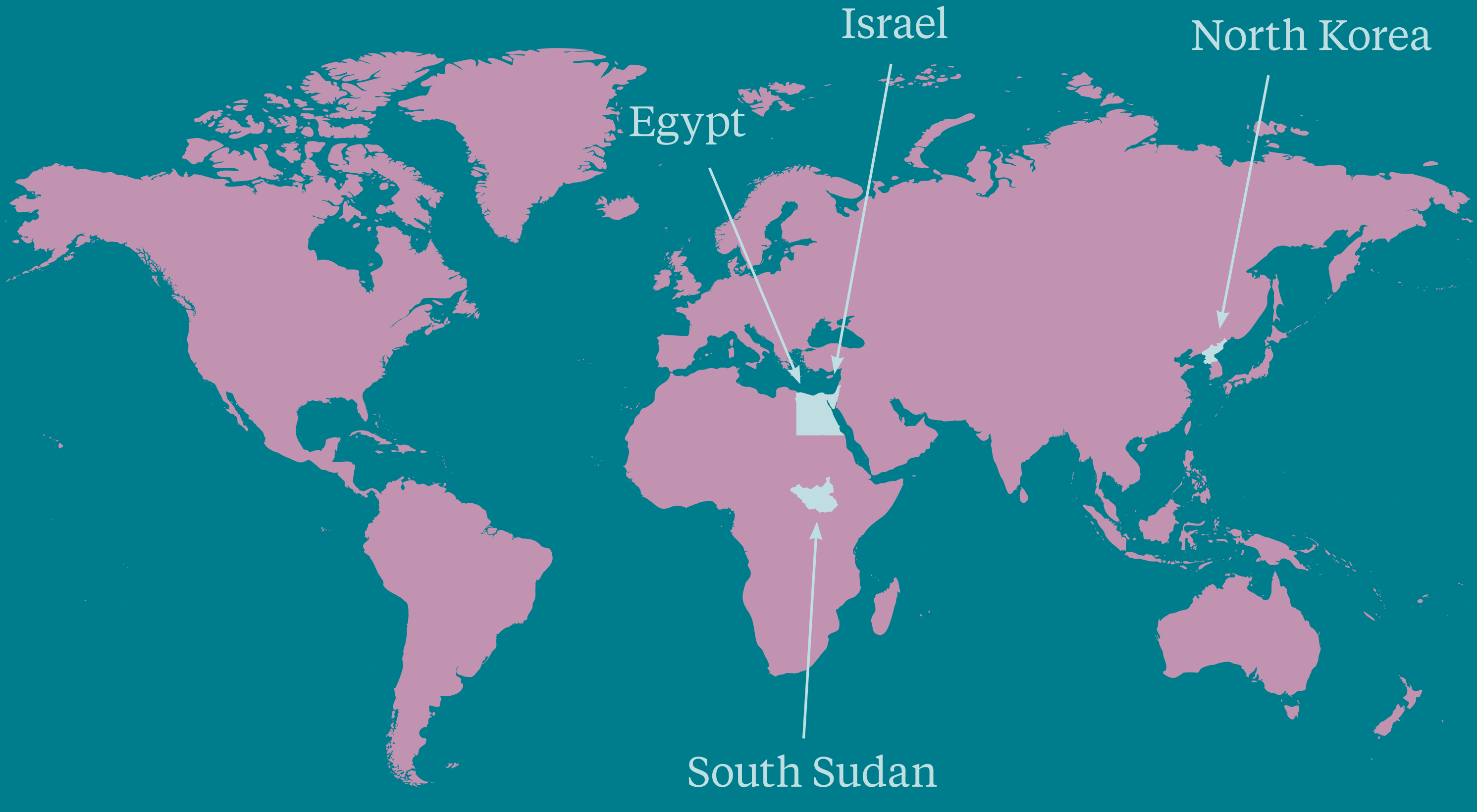
Under the BWC, complaints can be lodged with the UN Security Council – which can investigate them – but no complaint has ever been made and enforcement mechanisms do not exist. The CWC includes a provision for "challenge inspections" in case of suspected chemical weapons use – but again, it has never been invoked, not even in the case of Syria, though doubts about a chemical weapons programme are regularly debated at the Security Council. Over the last six years, regular visits by the "Declaration Assessment Team" have not been able to clarify discrepancies and determine if Syria's declaration is accurate and complete, and monthly reporting to the UN Security Council continues.

Additionally, the security context and shifting territorial control present significant challenges in ensuring that prohibition is fully implemented within the country. In cases of alleged use of chemical or biological weapons in countries not party to the conventions – like Syria in 2013 – investigations can be requested through the UN Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons, concluded in 1988.

Only four UN countries are not State Parties to the CWC (Egypt, Israel, North Korea and South Sudan). The highest concern among those is North Korea, said to possess large quantities of chemical weapons that could be sold or traded to unscrupulous non-State actors. It also needs to be mentioned that, while Russia announced in late 2017 it had destroyed its large chemical arsenal, that the United States has not been able to complete the destruction of its own arsenal, due to the cost and environmental challenges of chemical disposal. Both countries had requested extensions of the deadlines imposed by the Organisation for the Prohibition of Chemical Weapons, yet the existence of large stocks remains a risk.

In the 55 years since the BWC was negotiated, rapid advances in biotechnology have been made, which challenge our current governance models. The pharmaceutical and medical industries possess the tools and knowledge to develop biological weapons; the internet spreads this know-how to those who might use it for nefarious purposes. Biological threats do not respect borders and, as global travel increases, could quickly have a regional or even global impact. Terrorists could contaminate the water supply or release deadly bacteria, but it is also possible that the lack of lab safety could result in the inadvertent release of a virus or disease. The first step towards a solution would be to acknowledge the seriousness of the situation and create public health entities to handle any potential outbreak. But leadership is also needed to place this issue at the right place on the global agenda. This could come from the UN Security Council, the G7 or the G20, coalitions of government and industry bodies, civil society groups, or one or more nations acting as global champions.

# Only four UN countries are not State Parties to the Chemical Weapons Convention



Reviewed by
**DR JOANA CASTRO PEREIRA**

# Catastrophic climate change

## WHAT IS AT STAKE?

Catastrophic climate change has been associated with an increase in global average temperature of >3 °C[1]. This level of global warming would probably imply a serious shift in global climate patterns, unprecedented loss of landmass creating large flows of climate refugees, significant risks to regional and global food security, a combination of high temperature and humidity jeopardising normal human activities, as well as massive species extinctions having adverse cascading effects on ecosystem functioning and services critical for sustaining humanity[2].

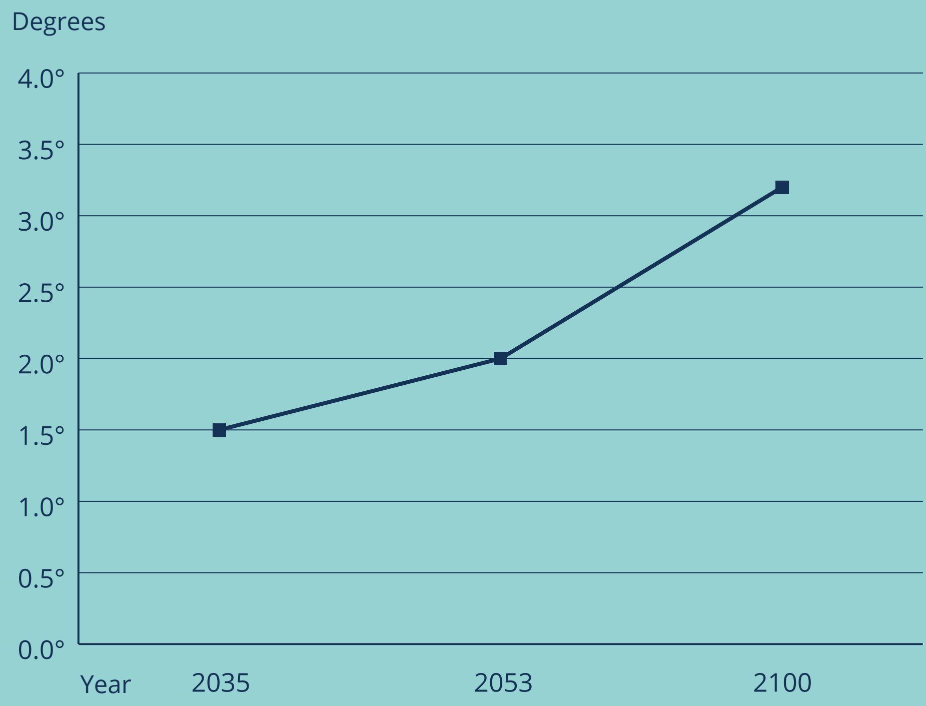
Catastrophic climate change would be triggered by crossing one or more tipping points of the Earth's climate system. Decision-makers have tended to assume that tipping points are of low probability and poorly understood. This is in spite of growing evidence that these tipping points may be more likely than previously thought, have high impacts and interact in complex and dangerous ways, threatening long-term irreversible changes[3]. Political discussions about climate change rarely acknowledge catastrophic climate risk[4].

## HOW MUCH DO WE KNOW?

The Earth's climate is impacted by the concentration of certain gases in the atmosphere known as greenhouse gases, the most important being carbon dioxide and methane. As a result of human activity since the Industrial Revolution, the atmospheric concentrations of greenhouse gases – generally expressed as the number of greenhouse gas molecules per million or ppm – have risen consistently, from 280 ppm at the dawn of the Industrial Revolution to 407 ppm in 2018. Current carbon dioxide levels are the highest in at least 800,000 years[5].

Climate change is accelerating and its impacts increasing. Human actions are estimated to be causing the planet's climate to change 170 times faster than natural forces. 2015-2019 and 2010-2019 were the warmest five and ten-year periods on record. Over the past decade, extreme weather, ice loss, sea level rise and ocean heat and acidification have accelerated[7].

**Human actions are estimated to be causing the planet's climate to change 170 times faster than natural forces.**




**Under current policies, global temperatures are expected to exceed 1.5 °C around 2035, 2 °C around 2053 and 3.2 °C by 2100.**

Human activities have caused approximately 1.0 °C of global warming above pre-industrial levels[8]. Under current policies, global temperatures are expected to exceed 1.5 °C around 2035, 2 °C around 2053 and 3.2 °C by 2100[9]. If countries fully achieve the emissions cuts they have committed to under the Paris Climate Agreement, the planet is likely to warm by approximately 2.9 °C by the end of the century[10]. Most of the world's major emitters are not even on track to meet their pledges[11].

Climate change is a non-linear phenomenon where tipping points play a determining role[12]. When warming rises above a certain level, self-reinforcing feedback loops set in and the concentration of greenhouse gases increases rapidly. Although precise thresholds and exact scenarios remain very uncertain, we know that the level of risk increases with the rise in temperature. The latest science suggests that tipping points could be exceeded even between 1.5°C and 2°C[13]. For example, at 2 °C of warming there is a 10-35% chance that the Arctic becomes largely ice-free in summer[14].

Scientists recently found that 45 per cent of all potential ecological collapses are interrelated and could reinforce one another[15]; in other words, 'exceeding tipping points in one system can increase the risk of crossing them in others'[16].

Limiting the Earth's temperature rise to 1.5 °C – the aspirational goal of the Paris Climate Agreement – is thus not only crucial for saving the majority of the world's plant and animal species[17] as well as safeguarding low-lying island states from sea level rise and the poorest countries from climate extremes[18], but also a precautionary step to prevent triggering climate tipping points. Nevertheless, countries must raise their level of ambition by over five times to reach the 1.5 °C goal[19].

According to the 2018 special report by the Intergovernmental Panel on Climate Change of the United Nations, the remaining carbon budget, to stand a reasonable chance (66%) of limiting warming to 1.5 °C would be depleted by around 2030[20]. The panel's conclusions were, however, criticised for being too conservative[21]. Considering, for example, an upper estimate of a wide range of potential Earth system feedbacks, humanity might have already exceeded the remaining budget to limit warming to 1.5 °C, (66% probability)[22]. Moreover, mitigation pathways compatible with 1.5 °C imply the deployment of negative emissions technologies (e.g., bioenergy production with carbon capture and storage)[23]. Science and policy advances in these fields  are currently far from ideal[24].

## CLIMATE TIPPING POINTS

The Earth's climate system is formed by large-scale components characterised by a threshold behaviour known as tipping elements. Put another way, climate tipping elements are supra-regional constituents of the Earth's climate system that may pass a tipping point[25]. The Greenland ice sheet and the Amazon rainforest are examples of tipping elements. A tipping point is 'a threshold at which small quantitative changes in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitative different state of the system, which is often irreversible'[26].

## WHAT ARE KEY FACTORS AFFECTING RISK LEVELS?

Climate change is a highly complex phenomenon affected by many factors. We may divide them into four categories to better discern the various areas where action is possible.

First, the risk is directly related to the release of greenhouse gases in the atmosphere through human activity. Carbon dioxide mainly results from the burning of fossil fuels for energy and transport. In turn, this is a factor in population growth and unsustainable production and consumption models[27].

As to methane emissions, they largely relate to large-scale animal farming, driven by demand for meat, dairy and wool[28].

Second, some ecosystems store large amounts of carbon, particularly forests and coastal marine ecosystems; their destruction could result in the large-scale release of greenhouse gases into the atmosphere[29].

The third factor is our capacity for global coordination to reduce emissions. This may be positively impacted by a better understanding of tail-end climate risk and climate tipping points, increasing the sense of urgency and prompting faster action[30].

Finally, the risk of catastrophic climate change is increased by insufficient knowledge and understanding of impacts and vulnerability, in turn affecting our ability to build resilience. The complex and interrelated nature of global catastrophic risk suggests an integrated research agenda to address related challenges and dilemmas and ensure human development and the protection of the non-human living beings that enable life on the planet to thrive. One such related challenge is the use of solar radiation management techniques (namely, stratospheric aerosol injection) to reduce the risk of catastrophic climate change, which might harm in other ways[31].


**▼There is a serious risk that political and public attention to climate issues will dramatically decline in the face of the pressing, severe economic and social consequences of the crisis.▼**

## The impact of the COVID-19 pandemic on climate change

The COVID-19 global health crisis will likely lead to a reduction in global carbon emissions in 2020. But how could the pandemic affect climate change in the mid to long-terms?

Some fear that the virus will weaken climate action. There is a serious risk that political and public attention to climate issues will dramatically decline in the face of the pressing, severe economic and social consequences of the crisis[32]. The next conferences of the parties of the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity, which would take place in the end of 2020 but have been postponed due to the pandemics, are critical for climate change mitigation and nature protection, as new emissions reduction commitments are expected to be presented and new global agreements on biodiversity concluded. In addition, governments may be tempted to pursuit short-term easy fixes with negative environmental impacts, e.g., rolling back environmental standards and subsidising fossil-fuel-heavy industries to stimulate the economy, prioritising indiscriminate economic growth over environmental sustainability imperatives[33].

In China, by the end of March, demand for energy and carbon emissions were already returning to normal levels following a 25 per cent reduction in emissions[34]. The country may also be considering relaxing emissions standards to help hard-hit carmakers[35]. Moreover, the economic impact of the crisis may undermine investments in clean energy[36] and further complicate the transfer of financial resources to assist developing countries in their climate change mitigation efforts.

Others believe that the COVID-19 crisis can be a turning point, giving rise to a greener future, as the economic recovery packages that are being prepared by many countries around the world offer an opportunity to re-build economies and societies towards sustainable modes of production and consumption[37].

**▼...global warming makes conditions more favourable to the spread of some infectious diseases and air pollution makes people more vulnerable to infection.▼**

## CLIMATE CHANGE, BIODIVERSITY LOSS AND HUMAN HEALTH

The COVID-19 global health crisis urges us to rethink our relationship to nature and the non-human species with which we share the planet. The coronavirus has been attributed to anthropogenic interferences on the natural world such as deforestation, a major contributor to climate change, encroachment on animal habitats, and biodiversity loss, which is also driven by climate change among other factors[38]. The pandemic is a reminder of our enmeshment in a more-than-human world[39]. It also calls our attention to the critical links between climate change and biodiversity loss, and their impacts on human health.

By eroding wild spaces for agriculture and changing the climate – thus forcing animals to find food and shelter close to people or migrate to escape heat – we are creating new opportunities for pathogens to get into new hosts. By trading and consuming wild animals, we increase the likelihood that zoonotic viruses will jump to humans.

Moreover, and although there is no direct evidence that climate change is influencing the spread of the new coronavirus, we know that global warming makes conditions more favourable to the spread of some infectious diseases and that air pollution makes people more vulnerable to infection[40]. We also know that when biodiversity declines, the species that thrive are the ones that are best at transmitting diseases e.g., bats and rats[41]. As current species extinction rates have no parallel in human history[42], there are strong reasons for concern. Finally, attention is also needed on the thawing of the Arctic's permafrost as a result of global warming and the possibility that viruses and bacteria once buried in the region are released[43].

Future policies must thus integrate climate, biodiversity and health considerations as well as the needs and rights of the non-human living beings with which we share the Earth.

# Governance of catastrophic climate change

**Dr Joana Castro Pereira,** Postdoctoral Researcher at Portuguese Institute of International Relations, NOVA University of Lisbon

The challenge of climate change has been defined as a 'super-wicked' problem. It is intricately linked to everything else – energy, land use, food, water, transportation, trade, development, housing, investment, security, etc.[44] Solving it requires tremendous, unprecedented collective action by countries with heterogeneous interests, priorities and circumstances [45], where powerful forces pushing for environmentally destructive development prevail[46]. The sharing of responsibility in mitigating climate change has thus been a central challenge in international negotiations[47].

The Paris Climate Agreement, signed in 2015 and in force since November 2016, avoids the critical issues of the allocation of responsibilities for safeguarding the climate and fairness of each country's mitigation efforts[48]. In addition, it fails to include:

- Dates by which countries must reach a global peaking of emissions,
- Legal obligations determining concrete mitigation actions,
- Means for coordinating the countries' contributions[49],
- Solid mechanisms for monitoring the implementation of national pledges and supporting the mitigation efforts of developing countries,
- Tools to punish the parties that do not comply with its provisions, and any references to the end of fossil fuel subsidies[50].

Moreover, the rules already established for operationalising the agreement provide very few obligations for countries to implement ambitious climate action at the domestic level. Other important guidelines remain undefined as parties have not reached consensus yet. These include rules to develop a global carbon trading system and how to channel new financial resources for helping countries already facing the adverse impacts of climate change[51].

In spite of the devastating fires, storms, social protests and climate strikes that swept the world in 2019, the last Conference of the Parties of the United Nations Framework Convention on Climate Change ended in failure. Countries such as Brazil, Australia and Saudi Arabia, 'invigorated by the US withdrawal from the Paris agreement and rising nationalism at home (...) defended loopholes and opposed commitments to enhance climate action'[52].

It thus appears highly unlikely that the international community will be able to prevent global warming from exceeding 1.5 °C. In this context, we need to prepare for dealing with the consequences of an increasingly unstable ecological environment and mitigating the risk of a climate catastrophe. There are, however, a number of limitations and obstacles that challenge our ability to do so[53].

The first is the fact that our brain is wired to process linear correlations, not sudden, rapid and exponential changes; our cognitive expectations are failed by the uncertainty and non-linearity of socio-ecological systems[54]. In addition, our political-legal system was developed to address structured, short-term, direct cause and effect issues (the exact opposite of the climate issue); our institutions provide simple solutions with immediate effects[55].

Managing catastrophic risks requires proactivity to anticipate emerging threats, mobilise support for action against possible future harm and provide responses that are sufficiently correct the first time, as those risks offer little or no opportunity for learning from experience and revising policies. Nevertheless, in addition to the fact that few existing institutions are capable of acting in this manner, there is the risk that such a proactive approach translates into oppressive behaviours and security measures[56].

The second is the possibility of creating a new risk through efforts to prevent another[57],e.g., large-scale deployment of bioenergy with carbon capture and storage to help prevent catastrophic climate change, which would erode natural habitats and cause the loss of biodiversity, thus increasing the risk of ecological collapse.

Third, mitigating the risk of a climate catastrophe requires that current generations resist short-term individual benefits with the aim of improving the far future of human civilisation. Many people lack motivation to help the far future[58].

Fourth, there tends to be a general distrust in human agency in the face of high-magnitude situations that demobilise people. In addition, people tend to experience strong, mobilising feelings about recent, visible events, and develop feelings of compassion especially when a subject is given a face; as societies have never lived a global climate catastrophe and nature is a vast and blurred subject, public and political concern for that possibility is low[59]. It remains to be seen whether the COVID-19 pandemic will make people more open to considering abrupt, high-impact situations.

Finally, averting a global climate catastrophe requires deep levels of global cooperation. Global cooperation is currently facing enormous challenges e.g., the rise of anti-globalisation nationalism and the 'Cold War' between the US and China over trade and technology.

More research is needed to increase our understanding of catastrophic climate risk, better reach the public and pressure political actors to act.

**…as societies have never lived a global climate catastrophe and nature is a vast and blurred subject, public and political concern for that possibility is low.**


Credit/source: Unsplash

…mitigating the risk of a climate catastrophe requires that current generations resist short-term individual benefits with the aim of improving the far future of human civilisation.

Reviewed by
**PHILIP OSANO**

# Ecological collapse

## WHAT IS AT STAKE?

Ecosystems are the foundation for human life. They perform a range of functions, generally referred to as environmental services, without which human societies and economies could not operate at their current level[1]. We depend on the services they provide for air, water, food and nourishment, shelter and energy. Ecosystems can tolerate a measure of impact from human use and recover relatively quickly with minimal negative effects – an attribute generally known as resilience – but beyond a certain threshold, or “tipping point”, sudden and radical disruption occurs[2]. Under such conditions, soil quality, fresh water supplies and biodiversity diminish drastically, while agricultural capacity plummets and daily human living conditions deteriorate significantly[3].

Local ecological collapse may have caused the end of a civilisation on Easter Island in the Pacific Ocean[4]. More recently, ecological collapse in and around the Aral Sea in Central Asia has had dramatic social and economic consequences for the region[5], although timely intervention has led to some marked recovery[6]. In today’s highly connected world, local disruptions may sometimes also lead to unintended ecological effects on other far flung areas. This might escalate into the rapid collapse of most ecosystems across the Earth[7]. With no time for effective recovery – and amplified by climate change impacts[8] – these disruptions could drastically compromise the planet’s capacity to support a large and growing human population sustainably.

**…beyond a certain threshold, or “tipping point”, sudden and radical disruption occurs.**

## HOW MUCH DO WE KNOW?

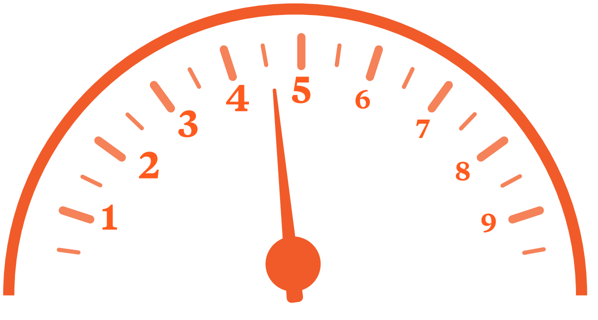
Ecosystems are complex entities which consist of a community of living organisms in their non-living environment, linked together through flows of energy and nutrients.

The behaviour of an ecosystem is relatively stable over time, but when the balance between some of its elements is altered beyond a certain threshold, it can experience a non-linear, possibly catastrophic transformation[9].

- Changes in the balance of local biodiversity caused by human intervention, in particular as a result of introducing new species or overharvesting of plants and animals[10]
- Alteration of the chemical balance in the environment due to pollution[11]
- Modifications in the local temperatures and water cycle because of climate change[12]
- Habitat loss, whether through destruction or ecosystem fragmentation in terrestrial and water/sea systems[13].

Human-induced factors that affect ecosystem vitality may be classified in the following manner: scholars describe the current historical moment as the start of a new geological era, called the Anthropocene[14], where humans, as the predominant agent of change at the planetary level, change the nature of nature itself. Since the mid-1950s, many elements that ensure the habitability of the planet, whether greenhouse gas concentration, forested areas or the health of marine ecosystems, have been degrading at an accelerating pace[15]. In 2009, an international group of experts identified nine interconnected planetary boundaries that underpin the stability of the global ecosystem, allowing human civilisation to thrive[16].

Each of the nine identified boundaries is characterised by thresholds or tipping points. Exceeding those carries a high risk of sudden and irreversible environmental change, which could make the planet less hospitable to human life.




**We have now exceeded the safe limits for four of the nine identified planetary boundaries**

The latest research indicates that, as a result of human activity, we have now exceeded the safe limits for four of the nine identified planetary boundaries[17].

It is argued that, having exceeded the safe limits for four of those boundaries, we are now operating in a high-risk zone for biosphere integrity and biogeochemical flows. As such, we are very likely to exceed all of the nine boundaries and move beyond the safe operating ecological space where humanity has thrived[18]. New evidence suggests that changing course to stop the pervasive human-driven decline of life on Earth requires transformative change[19].

## WHAT ARE KEY FACTORS AFFECTING RISK LEVELS?

The development and adoption of new technologies or production models that are less resource-intensive and/or less polluting could reduce the risk of biodiversity loss and ecological collapse, as would a shift towards more sustainable lifestyles, more specifically changing consumption patterns, possibly accompanied by behaviour change[20].

It is estimated that environmental services, should their contribution to human well-being be calculated, would be worth more than twice as much as the entire global GDP [21].

Integrating the valuation of ecosystems into economic decision-making and employing robust environmental accounting systems across businesses and national economies would contribute to reducing the risk[22].

Global governance mechanisms to conserve ecosystems and reduce pollution, in particular more integrated approaches between the global governance of ecosystems and trade, are of particular importance, as many ecosystems do not overlap with national boundaries, and trade is an important driver of ecosystem collapse[23].

## LAKE CHAD – An example of ecological collapse

The changes in Lake Chad have been called an ecological disaster that have not only destroyed livelihoods but also led to the loss of invaluable biodiversity. Lake Chad traverses Chad, Nigeria, Niger and Cameroon. The lake was considered the sixth largest lake in the world in the 1960s but over the last 60 years, its size has decreased by 90 per cent as a result of over-use of the water, extended drought and the impacts of climate change. The surface area of the lake has plummeted from 26,000 square kilometres in 1963 to less than 1,500 square kilometres today, affecting the livelihoods of over 40 million people who depend on it[24]. The fluctuation of the lake is attributed to the complex interaction of several factors, including the shallowness of the lake, changing human uses such as increased irrigation, and the effects of climate change[25]. A scientific assessment on the situation of the lake ranked freshwater shortage as severe and as a primary concern affecting other changes, including habitat modification and declining fish production[26]. The diminishing water resources and the decline in the lake's ecosystem leads to severe health and economic impacts for the populations around Lake Chad. It has affected fishing communities and pastoralists and generated resource-based conflicts[27].

# Governance of ecological collapse

**Philip Osano**, Research Fellow, Natural Resources and Ecosystems, Stockholm Environment Institute

Contemporary ecological risks are increasingly global in scale, scope and impact with strong levels of interconnection, not only across the borders of nations but across continents[28]. Action to address them, however, has to be taken at both global and national levels. The environment is a classic common good: everyone benefits from healthy ecosystems and a pollution-free planet, while extraction of natural resources and pollution by some compromise the benefit for many.

A number of international institutions oversee monitoring, assessment and reporting on problem identification and implementation. They set standards, policies and laws and they support the development of institutional capacity to address existing and emerging problems at the national level. Governments crafted the institutional architecture for managing global ecological risks in the 1970s with the creation of the anchor institution for the global environment: the United Nations Environment Program (UNEP). Global environmental conventions, also known as treaties or agreements, are the main international legal instrument for promoting collective action toward managing ecological risk and staying within the safe planetary operating space. Their number and membership have increased dramatically.

About a dozen international treaties deal with global issues including climate change, land-system change, biosphere change and chemicals and waste. These include the UN conventions on climate change, biodiversity, migratory species, trade in endangered species, desertification and persistent organic pollutants. The expectation is that when countries implement their obligations under the treaties, the problems will be managed and ultimately resolved. At the national level, governments have established ministries and authorities to deal with environmental concerns, advocate for ecologically informed decision making, and improve national capacity.

States voluntarily create international agreements to govern their relations through legal responsibilities. There is, however, no overarching judicial system or a coercive penal system that could ensure effective enforcement of the agreements that deal with environmental issues. Breaches cannot be sanctioned. Compliance and implementation have to be enticed rather than coerced. Environmental agreements such as the 2015 Paris Agreement, for example, are explicitly non-punitive: countries face no penalties for not meeting their commitments. Rather, they are facilitative, as international institutions commit to support compliance and implementation. The United Nations General Assembly Resolution 72/277, 'Towards a Global Pact for the Environment,' seeks to explore how to strengthen the implementation of international environmental law and international environmental governance[29].

**Contemporary ecological risks are increasingly global in scale, scope and impact with strong levels of interconnection.**

Importantly, many countries are implementing their obligations. The Environmental Conventions Index developed by the team at the Center for Governance and Sustainability at the University of Massachusetts, Boston measures the implementation of global environmental conventions. The Index is a composite score based on the national reports that member states submit to each convention secretariat and illustrates trends across countries, within countries (across issues and over time), and across the conventions. It highlights the leaders and the laggards and raises questions about the determinants of implementation. Availability of data, comprehensive regulations, national capacities, cooperation and funding emerge as important factors.

Reporting is the fundamental mechanism to entice and monitor implementation. National reports on progress in achieving global commitments are part of every agreement. Reporting, however, is a challenge because of low capacity and poor data in countries, an inadequate reporting system that does not always cover the comprehensive nature of the issues, and lack of analysis of and feedback on submitted reports. It is notable, however, that the complexity of the reporting process is not necessarily a deterrent to reporting compliance. The Ramsar Convention on wetlands, for example, requires countries to report on over 100 indicators and has among the highest reporting rates with member states reporting at close to 90 per cent of the time.

Enforcement mechanisms do not guarantee that international commitments will be implemented – or that problems will be solved. Countries, however, care about reputation and can be influenced by ratings and rankings, an approach to global performance assessment that has come to be known as scorecard diplomacy[30]. This form of soft power can shape national policies and outcomes as it goes beyond 'naming and shaming' to 'naming and acclaiming'. It outlines actions that could lead to better ranking and enables learning across peers. Scorecard diplomacy has proven effective in national governance, corruption, human trafficking, environmental democracy and environmental performance[31].

Since the 2015 Paris Agreement, progress on global efforts to address climate change has been slow, despite the growing threat that climate change and other human activities risk triggering biosphere tipping points across a range of ecosystems and scales[32]. Companies, cities and countries must raise their ambition to significantly take actions to reduce greenhouse gas emissions to below the 1.5 degree target and lead the transformation to a low carbon economy, which many see as desirable, inevitable and irrevocable.

**Importantly, many countries are implementing their obligations.**


**Enforcement mechanisms do not guarantee that international commitments will be implemented – or that problems will be solved.**

Reviewed by
**PROFESSOR DAVID L. HEYMANN**

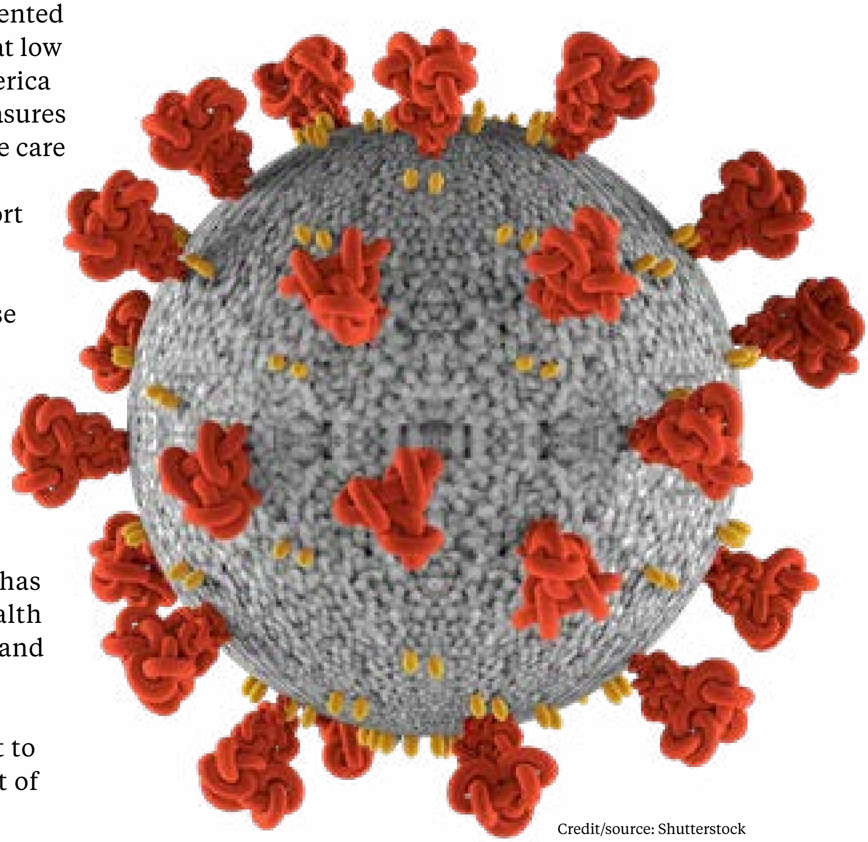
# Pandemics

### COVID-19 (SARS-COV-2)

The COVID-19 pandemic is thought to have originated from a virus that is carried by bats and emerged in human populations in Wuhan, China in late 2019. The virus spread extensively within China and through international travel. Proactive physical distancing measures - shutting down industrial, small business and air travel sectors, schools and public events – slowed the spread within China and internationally. Countries and other geographic areas in Asia that previously experienced SARS and MERS Coronavirus outbreaks rapidly implemented containment measures to keep transmission at low levels. As countries in Europe and North America became aware of outbreaks, containment measures helped decrease demand on hospital intensive care units. Countries in Africa and Latin America were, at the time of writing, beginning to report outbreaks. Although Sub-Saharan Africa is considered highly vulnerable, there has been extensive work by the Africa Centre for Disease Control and the World Health Organization (WHO) Regional Office to prepare countries with training in diagnostic testing and outbreak control, and to provide diagnostic testing materials as a means of strengthening their preparedness.

Understanding of this newly emerged virus has been rapid because scientific and public health experts freely share information with WHO and each other, despite overarching geopolitical tensions. This was also the case during the 2003 outbreak of SARS and during the effort to eradicate smallpox in the 1970s at the height of Cold War tensions.

The destiny of SARS-CoV-2 is not yet known – will it disappear from human populations and possibly return in the future like pandemic influenza and Ebola, or will it become endemic as did HIV that also emerged from the animal kingdom?



Credit/source: Shutterstock

> **Understanding of this newly emerged virus has been rapid because scientific and public health experts freely share information with the WHO and each other, despite overarching geopolitical tensions.**

## WHAT IS AT STAKE?

In the 5th and 14th century, Plague epidemics spread internationally and killed approximately 15 per cent of the global population over the course of a few decades[1]. Systematic vaccination campaigns have allowed us to eradicate two diseases that had affected humanity for centuries, Smallpox in humans and Rinderpest in animals. Two more diseases – Guinea Worm and Polio – are close to being eradicated. Progress in medical treatment and public health systems has significantly reduced the prevalence and impact of others, such as Malaria, Typhus and Cholera. However, there remains a serious risk that the emergence of a new infectious disease in humans could cause a major outbreak, with particularly high mortality and rapid spread in our densely populated, urbanised and highly interconnected world.

## HOW MUCH DO WE KNOW?

Catastrophic pandemics – diseases that spread globally, with high levels of mortality, are extremely disruptive. Outbreaks that remain locally contained or spread regionally and pandemics with lower levels of mortality are more common but can still have significant disruptive effects.

Outbreaks occur when a micro-organism – virus, bacteria, parasite, etc. – is able to spread across the population. At times, and under certain conditions, such as failure of water or sanitation systems, an outbreak is caused by a micro-organism known to be circulating at low levels in human populations. At others, an outbreak is caused by a micro-organism that has crossed the animal/human species barrier to infect humans and spreads to new and more densely populated areas. If mutation occurs, virulence and ability to transmit between humans can increase or decrease.

# RISK FACTORS[2]

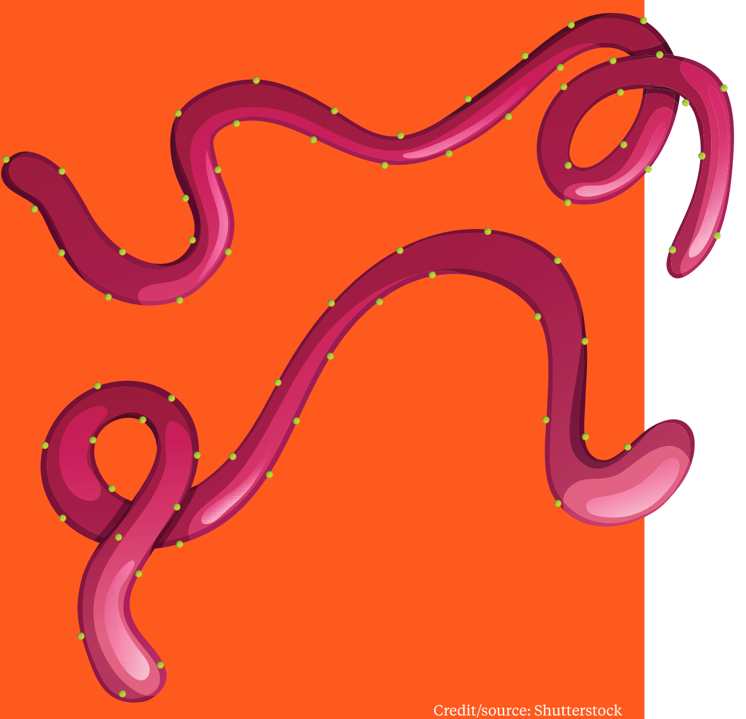
Three main factors determine the potential danger of an outbreak:

1. **Virulence:** the ability of a micro-organism to damage human tissues and cause illness and death.

2. **Infection risk:** the probability that a micro-organism will spread in a population. One key factor is the means of transmission – whether by blood, bodily fluids, direct contact with a lesion such as a skin ulcer, or by aerosolisation of infected droplets. Another is the immune status of the population – persons who are not immune are at greatest risk. For a new emerging infection in humans there has been no previous exposure and therefore no development of immunity.

3. **Incubation period:** the time between infection and appearance of the first symptom(s). A longer incubation period could result in a micro-organism spreading unwittingly, as in the case of HIV. Conversely, with a shorter incubation period, if the infection is highly lethal, it is less likely to be transmitted unwittingly, but it can still cause considerable disruption of social, economic and medical systems in a very short period of time. The disruption caused by a highly lethal infection with a longer incubation period, such as HIV, is of longer-term consequence.

Ebola is a highly lethal infection with a short incubation period but a relatively low infection rate, which explains why most Ebola outbreaks to date have remained localised[3]. New developments in synthetic biology, however, raise concern among certain scientists that an engineered micro-organism both highly virulent and with a high infection rate could be released in the population – whether by malice or accident – and cause an unprecedented outbreak, possibly leading to the international spread of a highly lethal infectious disease.



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## WHAT ARE KEY FACTORS AFFECTING RISK LEVELS?

New micro-organisms affecting humans are more likely to arise when environments with high levels of biodiversity are disrupted, and when humans or domesticated animals come into close contact with other animal species that serve as reservoirs for micro-organisms not yet present in human populations[4]. Experts now consider this is likely to be the way that the HIV/AIDS epidemic started[5].

Infections are easier to contain when they occur among small populations with limited external contacts. Conversely, dense urbanisation and global interconnection strongly increase the risk of an infectious disease spreading internationally[6].

Access to healthcare and the broad adoption of hygiene practices can have a significant effect in reducing the impact of a pandemic. This is especially true in health facilities where infection prevention and control through handwashing and other preventive measures can prevent transmission from amplifying into an outbreak. The capacity to monitor a disease and deploy very rapid containment early in the process also has a large impact on the final number of deaths[7].

## RISK SCENARIO

In February 2003, an elderly woman infected by the SARS virus travelled from Hong Kong to Toronto. SARS is a highly infectious and often fatal pulmonary disease that emerged in the Pearl River Delta in China. The infected woman died soon afterwards in Toronto, after inadvertently infecting over forty people, resulting in a localised outbreak. One of those persons infected in Canada went on a plane to the Philippines, where another outbreak occurred. Meanwhile, from Hong Kong, the virus had also spread to Singapore where it likewise caused an outbreak.

**▼New developments in synthetic biology... raise concern among certain scientists that an engineered micro-organism...could be released in the population – whether by malice or accident.▼**

The outbreaks that occurred around the world were eventually contained, through concerted public health action coordinated by the WHO, after infecting over 8,000 people, of whom 774 died. Severe social and economic disruption occurred, and a similar scenario with only minor variations – a few more international contacts, a slightly longer incubation period, or a few more days of delay in deploying strict containment measures – could have a similar or even more serious outcome.

### ANTIBIOTICS AND BACTERIA

Antibiotics have saved millions of lives and dramatically increased lifespans since they were introduced in the 1940s[8]. They have allowed us to contain most bacterial infections and diseases. However, more recently, as a result of random mutations, improper use of antibiotics among humans and animals, and the build-up effects of evolution, some strains of bacteria have become resistant to traditional antibiotics. These 'superbugs' require alternative medications with more damaging side effects. In the worst cases they can no longer be treated effectively. Antibiotic-resistant bacteria currently kill an estimated 700,000 people each year worldwide. That number is predicted to reach 10 million by 2050 if efforts are not made to curtail resistance or develop new antibiotics[9].

**Under the International Health Regulations, countries are required to strengthen core capacities in public health that are deemed necessary for rapid detection of, and response to, a disease outbreak.**

# Governance of pandemics

David Heymann, Head and Senior Fellow, Centre on Global Health Security, Chatham House,
Professor of Infectious Disease Epidemiology, London School of Hygiene & Tropical Medicine

The World Health Organisation (WHO), established in 1948 as a specialised agency of the United Nations, is currently the global body in charge of governing the risk of pandemics. It does this mainly through a governance mechanism called the International Health Regulations (IHR), the goal of which is to stop public health events, that have the potential to spread internationally, with minimal interference of travel and trade. The IHR first came into force in 1969, with an initial focus on four infectious diseases – Cholera, Plague, Yellow Fever and Smallpox.

Revised in 2005, the IHR now acknowledge that many more diseases than the four originally covered may spread internationally, and that many cannot be stopped at international borders, as was demonstrated by the spread of HIV in the 1980s and SARS in 2003. Emphasis is therefore now placed on the requirement that countries rapidly detect and respond to outbreaks and other public health events with potential to spread internationally. The revised version of the IHR also includes a global safety mechanism that calls for collaborative action should a public health event be assessed as at risk of spreading internationally.

The governance of pandemics typically involves collaboration between the WHO, ministries of health and public health institutions. Some nations have established Centres for Disease Control (CDC) whose role is to monitor transmissible public health events. Some of those, including the United States CDC and Public Health England, provide international support to developing countries, helping them strengthen their capacity to better detect and respond to public health events. When an outbreak occurs, other national institutions, hospitals in particular, play a major role in early detection and containment.

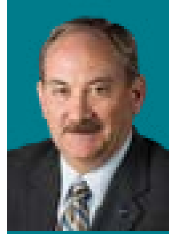
The IHR are a binding agreement under international law, and as such provide a framework for national legislation and responsible national and international action.

But like all international law and treaties, there is no enforcement mechanism. Under the IHR, countries are required to strengthen core capacities in public health that are deemed necessary for rapid detection of and response to a disease outbreak. Each year, countries are required to do a self-assessment of their core public health capacity, and to report the outcome of their assessment to the WHO. However, there is no sanction for non-reporting, and many countries do not report. As part of the IHR (2005) Monitoring and Evaluation Framework, the Joint External Evaluation (JEE) was developed as a mechanism where a country's core capacity in public health is assessed by a group of international experts. All countries may request such an evaluation through the WHO on a voluntary basis. The tool was made available in 2016 and to date, over 79 countries have done so.

The revised IHR provide a decision tree which can be used by countries to determine whether a public health event in their country has the potential for international spread and should therefore be reported as a potential public health emergency of international importance (PHEIC). The WHO Director-General then conducts a risk assessment. For this, they can ask for a recommendation from an emergency committee set up under the auspices of the IHR, and/or from other experts from around the world. If the Director-General decides that the event is a PHEIC, the WHO must provide emergency recommendations aimed at curbing international spread. It must review those recommendations every three months until the PHEIC has been declared over.

After the recent Ebola outbreak in West Africa, an external review of the revised IHR was conducted. At the time of writing, the World Health Assembly of the WHO is currently considering recommendations from that review.

Reviewed by **GERHARD DROLSHAGEN**



Reviewed by **LINDLEY JOHNSON**

Reviewed by **ROMANA KOFLER**

# Asteroid impact

## WHAT IS AT STAKE?

The largest near-Earth asteroids – those with a diameter of more than 1 kilometre – have the potential to cause geologic and climate effects on a global scale, disrupting human civilisation, and perhaps even resulting in the extinction of our species. Smaller near-Earth objects (NEOs) in the 140 metre to 1 km size range could cause regional or continental devastation, potentially killing hundreds of millions of people. Impactors in the 50 to 140 metre range are a local threat if they hit in a populated region and have the potential to destroy city-sized areas. NEOs in the 20 to 50 metre range generally disintegrate in Earth's atmosphere but can cause localised blast and impact effects.

The Chelyabinsk Event in Russia in 2013 is believed to have been caused by an airburst of an NEO with a 20 metre diameter. It caused localised damage in the city and injured nearly 1,600, mainly from debris and shattered glass from the blast.

## HOW MUCH DO WE KNOW?

Surveys of the NEO population since the 1990s have discovered more than 22,800 NEOs as of May 2020. A record 2,433 NEOs were discovered in 2019. In the United States, NASA's Planetary Defense Program has a congressionally directed requirement to discover at least 90 per cent of potentially hazardous asteroids larger than 140 metres across.

**The largest near-Earth asteroids – those with a diameter of more than 1 kilometre – have the potential to cause geologic and climate effects on a global scale, disrupting human civilisation, and perhaps even resulting in the extinction of our species.**

As of May 2020, 9,100 NEOs larger than 140 metres have been discovered. This is believed to be approximately 38 per cent of the total population of NEOs above this size.

Smaller asteroids are also continually being discovered, with the reservoir of NEOs with diameters between 50 and 140 metres expected to be approximately 300,000. This means these are the more likely impact threat in the near term. Impactors of these sizes are expected to have an average frequency of one per ~1000 years. The Tonguska event (1908) is believed to have been an impactor in the lower end of this size range.

### WHAT ARE KEY FACTORS AFFECTING RISK LEVELS?

The risk presented by an NEO is related to the probability of impact with Earth, the size and composition of the asteroid and the location of impact. The first step required in assessing the risk from larger NEOs is the completion of the census of NEOs larger than 140 metres across. Risk assessment also requires an observational assessment programme to refine knowledge of the orbit and to characterise the size and composition of the asteroid. This could include specialised ground and space-based observations, or a spacecraft reconnaissance mission to the asteroid.

Accurate orbital knowledge is required to establish the "impact corridor" – the areas on Earth where, given uncertainties in the orbital knowledge, the impact is most likely to occur. The size and composition of the asteroid are used to model impact effects and determine the potential severity of an impact.

In the event of a credible impact threat prediction, warnings will be issued by the IAWN if the object is assessed to be larger than 10 metres. If the object is larger than about 50 metres and the impact probability is larger than 1 per cent within the next 50 years, the SMPAG would start to assess in-space mitigation options and implementation plans for consideration by the Member States. The goal is the global protection of human civilisation and our ecosystem. With vigilance and sufficient warning, an asteroid impact is a devastating natural disaster that can be prevented.

**The goal is the global protection of human civilisation and our ecosystem.**

# Governance of asteroid impact

**Gerhard Drolshagen**, University of Oldenburg and the European Space Agency

**Lindley Johnson**, NASA Planetary Defense Officer and Program Executive of the Planetary Defense Coordination Office

**Romana Kofler**, United Nations Office for Outer Space Affairs

International cooperation and coordination in the area of near-Earth objects is crucial, given the potential global consequences of an impact and the significant resources that would be required to mitigate such a collision event. The issue has long been on the agenda of the Committee on the Peaceful Uses of Outer Space (COPUOS), the primary United Nations body for coordinating and facilitating international cooperation in space activities. It was established in 1959 by the UN General Assembly and supported by the Office for Outer Space Affairs (UNOOSA)[1].

Under the auspices of COPUOS, several recommendations for strengthening international cooperation and responses to the risk of an NEO impact have been made. This led to the establishment in 2014 of the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG). These bodies provide mechanisms at the global level to address the challenge posed by NEOs. This includes detection, tracking and impact risk assessment as well as planetary defence measures like civil protection or asteroid deflection.

UNOOSA, through the warning network and the advisory group, facilitates the dissemination of information on NEOs to UN Member States. Important linkages are being made with civil protection communities, including through UNOOSA's UN-SPIDER programme and its global network of Regional Support Offices (RSOs). Their goal is to sensitise governments and their relevant national authorities about the existence of NEOs as potential natural disaster hazards, urging them to address the risk as part of their national emergency response and preparedness strategies.

### *IAWN and SMPAG - global mechanisms for coordinating action in the area of planetary defence*

The IAWN links together the institutions that are already performing many of the proposed functions, including discovering, monitoring and physically characterising potentially hazardous NEOs. One of its aims is to maintain an internationally recognised clearing house for the receipt, acknowledgment and processing of all NEO observations. This is accomplished by the International Astronomical Union sanctioned Minor Planet Center, hosted at the Smithsonian Astrophysical Observatory in the United States and supported by NASA's Planetary Defense Coordination Office.

IAWN recommends policies for gauging an emerging impact threat. It also assists governments to analyse the possible consequences of impact and to plan their responses. As of May 2020, there are 25 official signatories to the IAWN Statement of Intent, representing observatories and space institutions from Canada, China, Colombia, Croatia, Israel, Mexico, the Republic of Korea, Russia and the United States, as well as independent astronomers from the United Kingdom, Brazil, Spain, Italy, Russia and the United States.

The SMPAG, (pronounced "same page") is composed of Member States with space agencies or inter-governmental entities that coordinate and fund space activities and are capable of contributing to or carrying out a space-based near-Earth object mitigation campaign. Its responsibilities include developing the framework, timeline and options for initiating and executing space mission response activities, as well as promoting opportunities for international collaboration on research and techniques for NEO deflection. SMPAG currently has 19 members and six permanent observers, with UNOOSA acting as its secretariat.

***International Asteroid Day***
As part of the effort to raise awareness about this topic, the UN General Assembly proclaimed in resolution A/71/492 that International Asteroid Day would be observed annually on 30 June. 30 June is the anniversary of the Tunguska impact over Siberia in the Russian Federation on 30 June 1908. It was the Earth's largest confirmed asteroid impact in recorded history, devastating over 2,000 square kilometres of forest.

***International Planetary Defense Conference (PDC) 2021***
As the key biannual global conference that brings together key experts in this area, the 7th International Planetary Defence Conference will be hosted by UNOOSA from 26 to 30 April 2021 at the Vienna International Centre, Vienna, Austria.

**International cooperation and coordination in the area of near-Earth objects is crucial, given the potential global consequences of an impact and the significant resources that would be required to mitigate such a collision event.**

Reviewed by
**STEPHEN SPARKS**

# Supervolcanic eruption

The eruption of the Toba supervolcano in Indonesia, around 74,000 years ago, ejected billions of tonnes of dust and sulphates into the atmosphere[1]. Experts estimate that it caused a global cooling of 3-5°C for several years and led to devastating loss of plant and animal life[2]. Some have argued that Toba caused the greatest mass extinction in human history, bringing our species to the brink of extinction[3]. Supervolcanic eruptions are events in which at least 400 km3 of bulk material is expelled. Eruptions of such magnitude may happen at any time in the future, with catastrophic consequences.

### HOW MUCH DO WE KNOW?

In order to assess the likelihood of supervolcanic eruptions, we have to rely on a relatively limited set of past observations, which makes any estimates very uncertain[4]. Existing data suggest that a supervolcanic eruption will occur every 17,000[5] years on average – with the last known event occurring 26,500 years ago in New Zealand[6]. We are currently unable to anticipate volcanic eruptions beyond a few weeks or months in advance, but scientists are monitoring a number of areas, including Yellowstone in the US[7], which have been identified as potential sites of a future supervolcanic eruption. The impact of a supervolcanic eruption is directly connected to the quantities of materials ejected by the volcano.

**The eruption of the Toba supervolcano in Indonesia, around 74,000 years ago… caused a global cooling of 3-5°C for several years…some have argued that Toba caused the greatest mass extinction in human history.**

Dust and ashes will kill human populations nearby and devastate local agricultural activity. In addition, the release of sulphate and ashes in the atmosphere will affect the amount of solar energy reaching the surface of the planet and may lead to temporary global cooling[8] and severe environmental effects[9].

## What are key factors affecting risk levels?

- There is no current prospect of reducing the probability of a supervolcanic risk, but there may be ways to mitigate its impact[10].
- Improvements in our ability to identify volcanoes with potential for future super-eruptions – and to predict eruptions – will help us to prepare and ensure that food stockpiles are available to mitigate a temporary collapse of agricultural systems.
- Resilience building, particularly the potential to rely on food sources less dependent on sunlight – including mushrooms, insects and bacteria – could significantly reduce the death rate among humans[11].

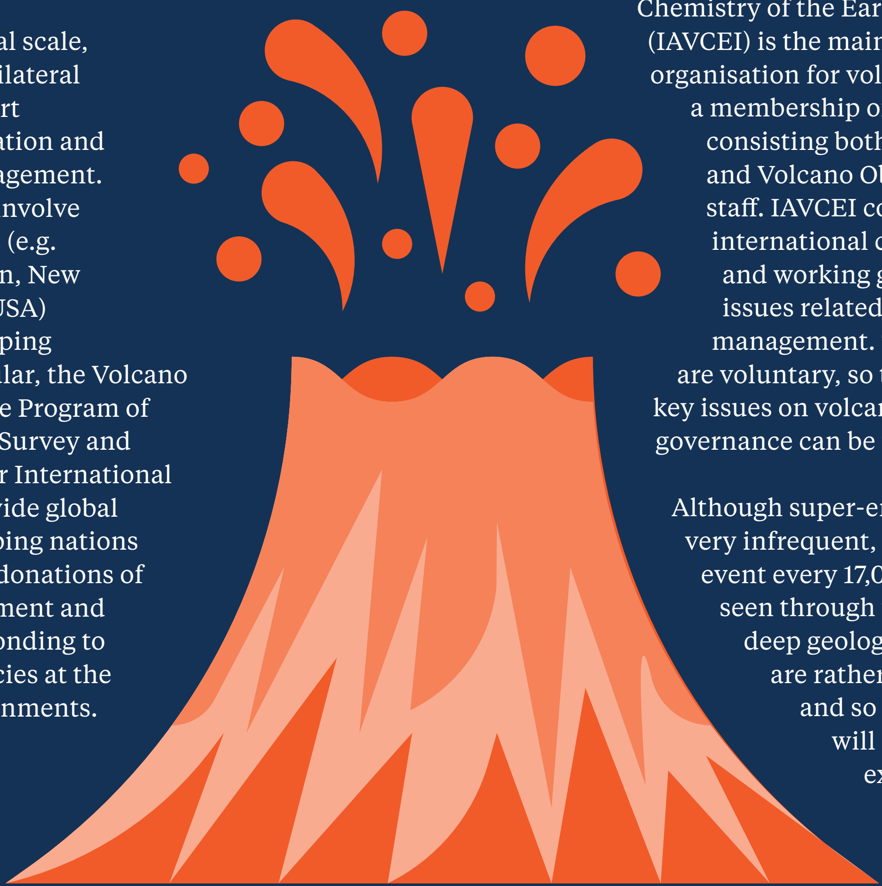
**▼Although super-eruptions are very infrequent, seen through the lens of deep geological time they are rather common.▼**

# Governance of supervolcanic eruption

**Stephen Sparks**, Professor, School of Earth Sciences, University of Bristol

Monitoring volcanoes is largely a responsibility of national institutions that operate Volcano Observatories, and work with political authorities, civil protection agencies and communities to manage the risk. Over the past century, these institutions have been set up in many countries to monitor either a single volcano or multiple volcanoes: the World Organisation of Volcano Observatories lists 80 Volcano Observatories in 33 countries and regions, and plays a coordinating role among them. In countries with infrequent eruptions and no Volcano Observatory, national institutions responsible for natural hazards would be responsible for monitoring the risk.

On an international scale, bilateral and multilateral agreements support scientific investigation and volcanic risk management. These commonly involve developed nations (e.g. France, Italy, Japan, New Zealand, UK and USA) supporting developing nations. In particular, the Volcano Disaster Assistance Program of the US Geological Survey and the U.S. Agency for International Development provide global support to developing nations through training, donations of monitoring equipment and assistance in responding to volcanic emergencies at the invitation of governments.



In addition, an international network of nine Volcanic Ash Advisory Centres issues warnings of volcanic ash eruptions into the atmosphere to protect aviation, with world-wide coverage. Apart from those, there is no organisation or institution that has a mandate to manage volcanic risk on a global scale.

More informal global coordination is achieved through voluntary international and regional organisations, networks and projects that coordinate the sharing of scientific knowledge, technical expertise and best practice. The International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) is the main scientific organisation for volcanology with a membership of over 1000, consisting both of academics and Volcano Observatory staff. IAVCEI co-ordinates international commissions and working groups on many issues related to volcanic risk management. These activities are voluntary, so the coverage of key issues on volcanic risk and its governance can be uneven.

Although super-eruptions are very infrequent, (an estimated event every 17,000 years), seen through the lens of deep geological time they are rather common, and so humanity will eventually experience one.

Volcanoes with potential for future super-eruptions either have a past record of super-eruptions or have been long dormant. Known sites include volcanoes in the USA, Japan, New Zealand, Turkey and several South American countries, but identifying potential future sites of eruptions with no previous record is significantly more challenging.

The existing system provides an effective, though imperfect, structure to manage local volcanic risk. Depending on the magnitude of the event, the system is likely to come under pressure and prove inadequate in the event of a catastrophic eruption with global reach. No organisation has a specific mandate to address risk from super-eruptions. If one occurred in a populated location, we could anticipate an immediate major humanitarian crisis, with overwhelmed institutions and services, and long-term effects on the environment, climate, critical infrastructure, food security and global trade. Developing a global response plan under the auspices of a UN agency and IAVCEI would be a good start to improve governance of this global risk.

A recent synthesis of global volcanic risk and its governance can be found in endnote 17 for this section.

## VOLCANIC ERUPTIONS

Volcanic eruptions are measured through a magnitude scale, a logarithmic scale, ranging from 0 to 9, where each unit increase indicates an eruption 10 times greater in erupted mass[12]. At the top of the scale, supervolcanic eruptions (M 8) release more than 400 km3 of magma. By comparison, the largest volcano eruption recorded in human history, the 1815 Tambora eruption in Indonesia, had a magnitude of about 7:41 km3 of magma expelled[13], claiming over 70,000 lives[14]. When Mount Vesuvius erupted in 79 AD, devastating the Roman cities of Pompeii and Herculaneum, it released approximately 4 km3 of magma, placing it at magnitude 6[15]. More recently, the May 1980 eruption of Mount St. Helens in Washington, USA, with just over 0.5km3 released, was a magnitude 5.1[16].

Reviewed by
**ARIEL CONN**

# Artificial Intelligence

## WHAT IS AT STAKE?

Human intelligence has led to the greatest triumphs of humanity, but it is also behind some of history's greatest catastrophes. So what happens if we create artificial intelligence (AI) that's significantly smarter than any person? Will it help us reach even greater heights or will it trigger, as some experts worry, the greatest catastrophe of all: human extinction?

Today's artificial intelligence systems already outperform humans in the tasks they were trained for, especially when it comes to the speed with which they act. In just a matter of seconds, an AI system can play the winning move in Chess or Go, translate an article, or plot a route to a given destination while taking into account current traffic patterns.

Though a human requires more time to do any of these, a key aspect of human intelligence is that we can perform all of these tasks. We have what's known as general intelligence. While AI systems can only perform the tasks they were trained to do, a human can learn from context and experience and develop new skills or solve novel problems.

Many experts worry that if an AI system achieves human-level general intelligence, it will quickly surpass us, just as AI systems have done with their narrow tasks. At that point, we don't know what the AI will do.

## WHY IS THIS A RISK?

First, it's important to note that experts are not worried that an AI will suddenly become psychopathic and begin randomly hurting or killing people. Instead, experts worry that an AI programme will either be intentionally misused to cause harm, or it will be far too competent at completing a task that turned out to be poorly defined.

Just looking at some of the problems caused by narrow AI programmes today can give us at least some sense of the problems an even more intelligent system could cause. We've already seen that recommendation algorithms on social media can be used to help spread fake news and upend democracy. Yet even as AI researchers race to find ways to prevent the spread of fake news, they worry the problem will soon worsen with the rise of Deepfakes – in which AI programmes modify what's seen or heard in a video without the viewer recognising it's been doctored.

At the same time, AI systems that were deployed with the best of intentions to identify images, parse through job applications, or minimise mindless tasks have instead inadvertently reinforced institutional racism, put jobs at risk, and exacerbated inequality.

It's not hard to imagine how much worse these problems could get with advanced AI systems functioning across many platforms or falling into the hands of terrorists or despots.

## WHAT DO WE KNOW?

Though science fiction often portrays artificial intelligence systems as humanoid robots, the AI systems we interact with in our daily lives are typically algorithms running in the background of some programme we're using. They work so seamlessly that people outside of the AI world often don't even realise they've just interacted with artificial intelligence.

## WHAT IS ARTIFICIAL INTELLIGENCE

For now, these programmes can only perform those narrow tasks. But it is widely accepted that we will be able to create AI systems capable of performing most tasks, as well as a human, at some point. According to the median surveyed expert, there is a roughly 50 per cent chance of such AI by 2050 – with at least a five per cent chance of super-intelligent AI within two years after human-level AI, and a 50 per cent chance within thirty years[1]. The long-term social impact of human-level AI and beyond, however, is unclear, with extreme uncertainty surrounding experts' estimates.

Credit/source: iStockphoto

# AI for Good: Beating pandemics

If AI poses such a threat to humanity, why develop it? Most AI researchers go into the field precisely because the technology promises to do so much good. The COVID-19 pandemic highlights some of the ways in which AI can help improve the world.

- **Sift through data:** Perhaps AI's greatest skill to date is parsing and analysing huge quantities of data. This was put to use in a partnership between the White House Office for Science and Technology and a number of AI companies and non-profits who joined forces to create a database[2] that tracks medical journal articles related to the COVID-19 pandemic. It's helping doctors and scientists search through tens of thousands of articles to better treat and prevent the coronavirus.

- **Identify illness:** AI systems are increasingly proficient at recognising anomalies in x-rays, so it's no surprise they're being used to identify the coronavirus in chest x-rays.

- **Drug development:** AI is already used to develop novel drugs to treat disease, and a handful of companies have turned to AI to model which existing drugs might help fight the virus, as well as what new drugs could be developed to help save more lives.

- **Track the spread of a pandemic:** This work is still in beginning stages, but if another pandemic strikes, we may be able to use AI systems to identify the threat early, so we can stop the spread of the disease before anyone realises that the threat exists.

- **Ensuring social distancing:** Robots could be deployed in some cases to help minimise exposure to disease, for example in disinfecting a space, and apps could help track who has travelled where and who is standing too close to whom. AI and robotics systems could also be deployed to track hospital activities to maximise treatment for patients while minimising exposure to nurses and doctors.

## WHAT ARE KEY FACTORS IMPACTING RISK LEVELS?

AI risk is still emerging today but could rapidly accelerate if sudden technological breakthroughs left inadequate time for social and political institutions to adjust risk management mechanisms. If AI development gets automated, in particular, new capabilities might evolve extremely quickly.

Risks can be exacerbated by geopolitical tensions leading to an AI weapons race, AI development races that cut corners on safety, or ineffective governance of powerful AI.

The level of AI risk will partly depend on the possibility of aligning the goals of advanced AI with human values – which will require more precise specification of human values and/or novel methods by which AIs can effectively learn and retain those values.

The current quest for Artificial General Intelligence (AGI) builds on the capacity for a system to automate predictive analysis – a process generally described as machine learning. One important element of machine learning is the use of neural networks: systems that involve a large number of processors operating in parallel and arranged in tiers. The first tier receives a raw input; each successive tier receives the output from the tier preceding it. Neural networks adapt and modify themselves autonomously, according to initial training and input of data, in ways that are typically not transparent to the engineers developing them.

If researchers one day succeed in building a human-level AGI, it will probably include expert systems, natural language processing and machine vision as well as mimicking cognitive functions that we today associate with a human mind, e.g., learning, reasoning, problem solving, and self-correction. However, the underlying mechanisms may differ considerably from those happening in the human brain just as the workings of today's airplanes differ from those of birds[3].

**...it is widely accepted that we will be able to create AI systems capable of performing most tasks as well as a human at some point.**

# Governance of artificial intelligence

**Ariel Conn**, Founder and President, Magnitude 10 Consulting

In recent years, the risks of artificial intelligence have become much more tangible, with real-world threats appearing regularly in news articles. The most well known problems surround Facebook, with the Cambridge Analytica scandal and the use of AI and fake news to interfere with elections. But countless AI issues and concerns have graced the covers of prominent news sites, leading the public and government officials alike to consider the development of AI with more scrutiny.

The Organisation for Economic Co-operation and Development (OECD) AI Policy Observatory[4] has identified "over 300 AI policy initiatives from 60 countries," including 36 policy initiatives in the United States and 22 in the European Union. Though the focus of AI policy in various countries has had more to do with research and development -- such as China's plan to become the world leader in AI by 2030 and the American Artificial Intelligence Initiative[5] -- many efforts do mention safe and beneficial AI.

Additionally, many organisations have taken it upon themselves to create their own principles and guidelines to develop AI for good.

In late 2019, researchers published a Global Landscape of AI Ethics[6], in which they "identified 84 documents containing ethical principles or guidelines for AI," 88 per cent of which were released after 2016. These documents were written by some of the world's most prominent companies and organisations, including groups like Google, SAP, the European Commission's High Level Expert Group on Artificial Intelligence, the OECD, IEEE's Ethically Aligned Design, the UK House of Lords, the US Department of Defense (the latter adopted AI principles after the Landscape paper was published), and many more.

The Landscape paper found "eleven overarching ethical values and principles have emerged": "transparency, justice and fairness, non-maleficence, responsibility, privacy, beneficence, freedom and autonomy, trust, dignity, sustainability, and solidarity."

To address these issues, some non-governmental groups, like AI Now, have been tracking problems that are already cropping up with AI, including bias, racism, discrimination, violations of human rights, job loss and more. Meanwhile, other groups have focused on emphasising and supporting AI developed for good, including the United Nations AI for Good Global Summit and the nascent US$1 million AAAI Squirrel AI Award for Artificial Intelligence for the Benefit of Humanity.

Legislation is still in early stages, and experts anticipate governments will become increasingly interested in AI development and use. For now though, companies and countries face minimal oversight as they develop AI.

## AUTONOMOUS WEAPONS

Autonomous weapons systems are weapons that could select and attack a target, without someone overseeing the decision-making process.

Though fully-autonomous weapons don't exist yet, the idea of such weaponry has triggered intense ethical and legal debates around the world, as people try to determine the extent to which an algorithm can decide who lives and who dies and how. Member states of the United Nations Convention on Conventional Weapons have considered this question for many years but have yet to find consensus on legal definitions or on regulations regarding the development and use of such weapons.

Meanwhile weapons systems are becoming increasingly autonomous; without clear definitions regarding what's acceptable and unacceptable, many experts expect we'll have autonomous weapons systems in a matter of years.

Autonomous weapons pose another threat too: if countries race to develop more powerful autonomous weapons, they could inadvertently find themselves in a race for advanced AI more generally. In such a situation, developers may cut corners or get sloppy in their efforts to be the first to create something new, and the resulting artificial intelligence systems are more likely to behave unpredictably or cause problems in some way.

**Though fully-autonomous weapons don't exist yet, the idea of such weaponry has triggered intense ethical and legal debates around the world, as people try to determine the extent to which an algorithm can decide who lives and who dies and how.**

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## ASTEROID IMPACT


1. The Office for Outer Space Affairs (UNOOSA) acts as the secretariat to the Committee and is responsible for advancing international cooperation in the peaceful uses of outer space and the use of space science and technology for sustainable development.


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